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Characteristics and Development of the W89 High-Voltage, Low-Inductance Interconnect

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Prepared by
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Albuquerque, New Mexico 87185 and Livermore, California 94550
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Characteristics and Development of the W89 High-Voltage, Low-Inductance Interconnect

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Abstract

This report documents the development and test results of a contact and seal assembly, to be used as a high-voltage, low-inductance interconnect on the W89/Pit Reuse for Enhanced Safety and Security (PRESS). The report describes the reasons behind the project, the different design concepts and materials, the solutions to various design problems, and the indications of the test results.

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Characteristics and Development of the W89 High-Voltage, Low-Inductance Interconnect

Purpose of the Development

Sandia National Laboratories/California and Lawrence Livermore National Laboratory (LLNL) requested the development of a high-voltage, low-inductance (HVLI) interconnect for use on the W89 MC4069 Firing Set. The HLVI would interface with three connections:

- The series connection, located under the MC4069 in the firing set deck.
- The main connection, located near the base of the MC4069 where the main capacitor discharge unit (CDU) cable exits.
- The neutron generator (NG) connection, located near the top of the MC4069 at the NG CDU output.

The interconnect had to operate at altitude while providing electrical contact between two high-voltage, two-conductor, flat cables with inductance less than 10 nano-henries.

Concept Evaluation of Four Designs

To establish the best solution for the application, we evaluated four design concepts. The first design (Figure 1) used a solid copper, 0.050-in.-thick pad soldered to one of the flex cables. A compression pad was placed behind the mating cable to force it to make contact with the copper pad. A second design (Figure 2), which did not require a compression pad, replaced the solid copper contact with a spring contact. The third design (Figure 3), which used no contacts, placed a compression pad behind both cables. All three designs had a separate silicone rubber seal that provided voltage standoff at altitude. The final design, a contact and seal assembly (CSA) (Figures 4 through 6), used a thermoplastic holder (which captured the beryllium copper spring contacts) and a silicone rubber seal molded into the holder for voltage standoff.

Through Integrated Contract Order 63-5160, Allied Signal/KCD developed fabrication methods and performed evaluation on all of the designs. Table 1 lists the tests that they performed, and Table 2 shows the results of those tests.

For example, with the solid contacts, we found:

- Open circuits at low temperature
- Badly deformed mating cables around raised contact areas
- Gold embrittlement in the solder joint that held the contact in place.

With the spring contacts, we found:

- Hi-pot failures, possibly because of foreign material
- Gold embrittlement in the solder joint that held the contact in place.

The flat, or flush, contacts showed open circuits at low temperature.

Because of the above results, problems with manufacturing, and damage from handling, we decided on the CSA design.

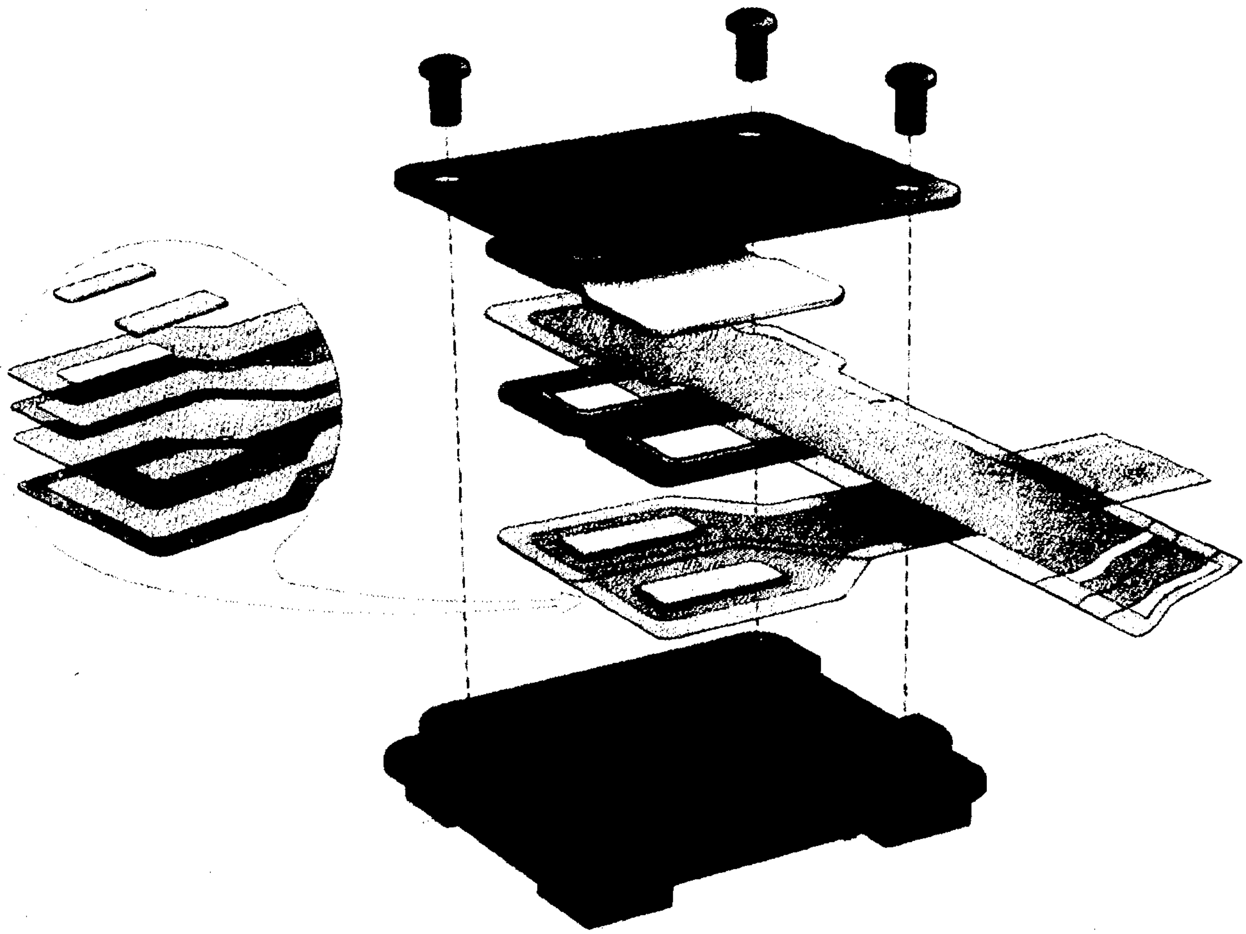

Figure 1. Main CDU Solid Contact Design

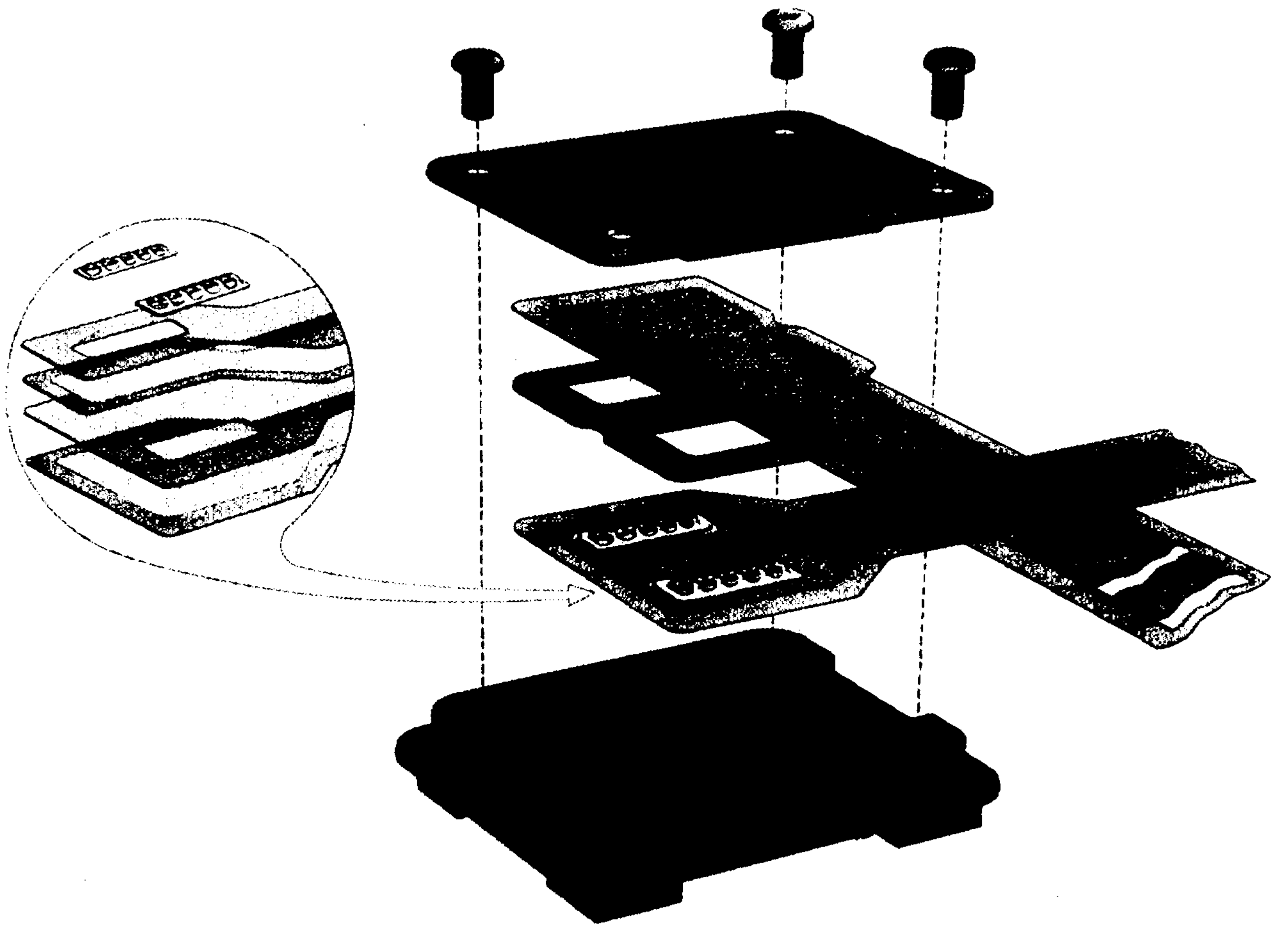

Figure 2. Main CDU Spring Contact Design

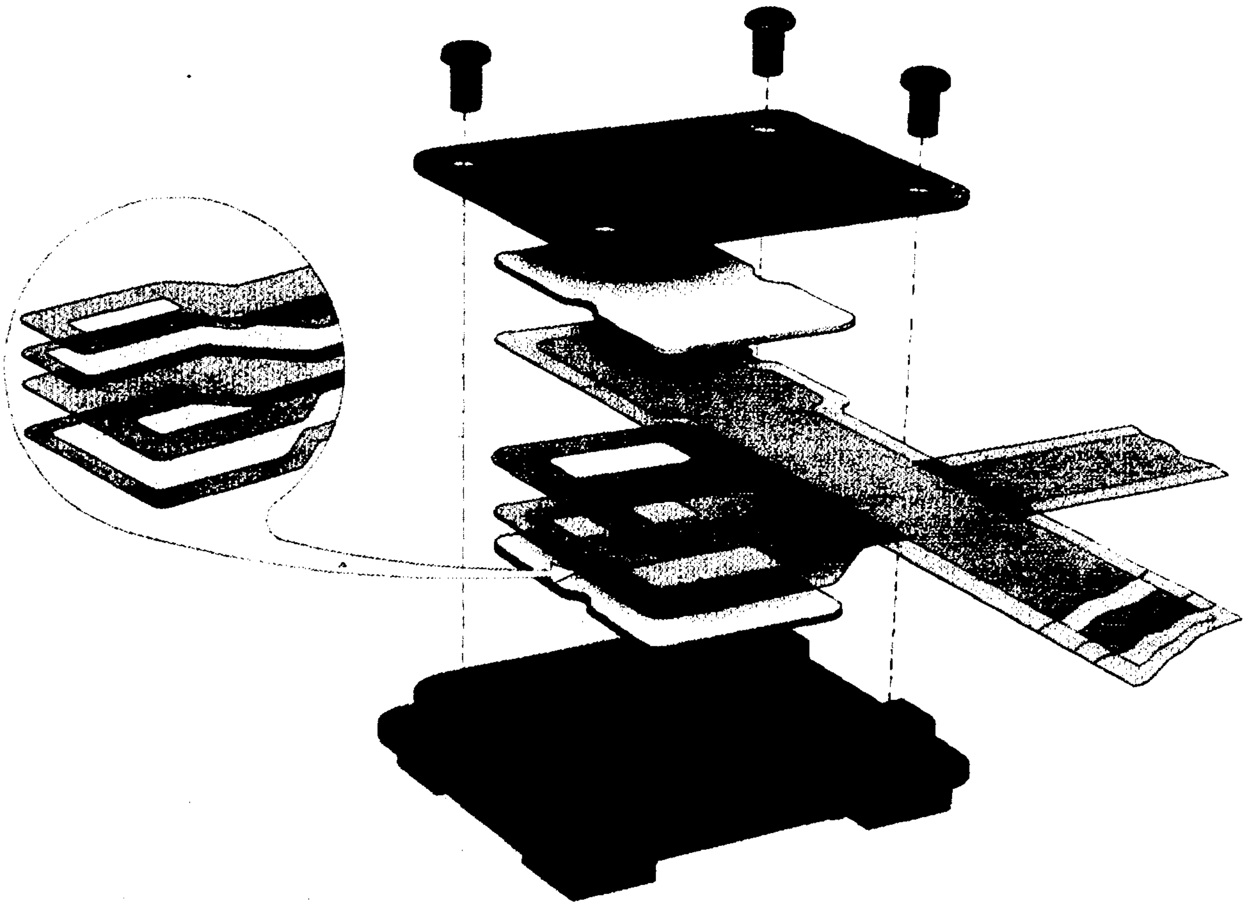

Figure 3. Main CDU Flat Contact Design

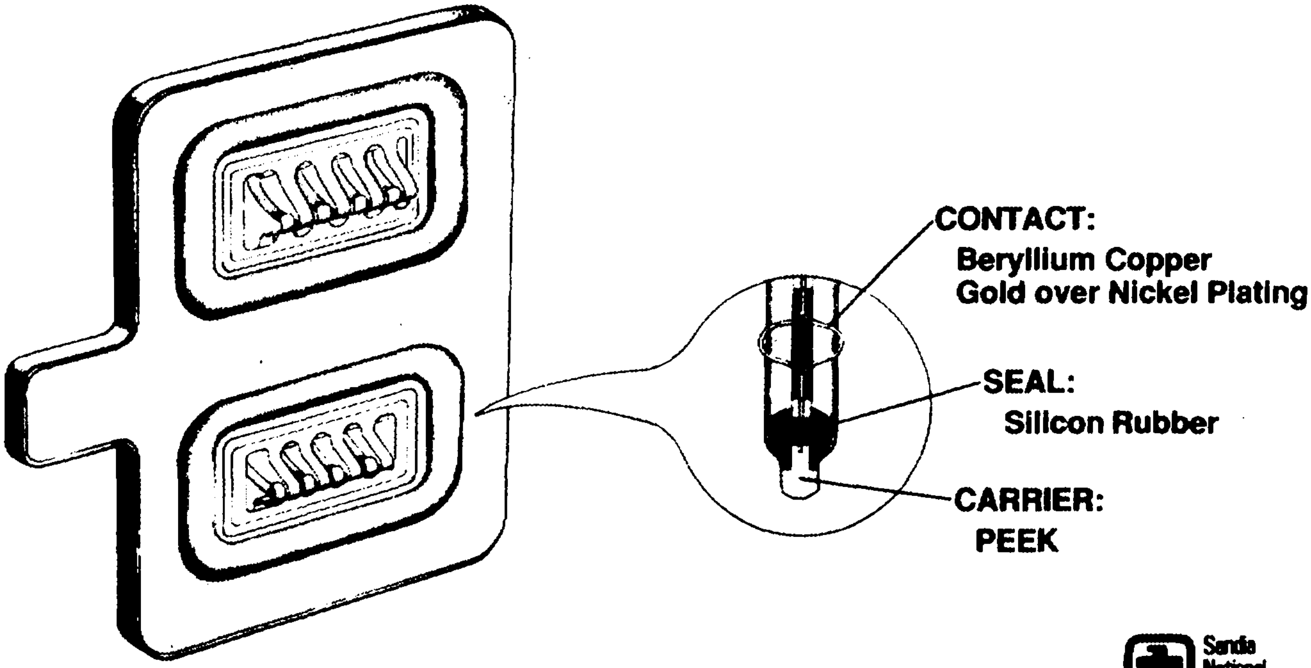

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Figure 4. Main Contact and Seal Assembly

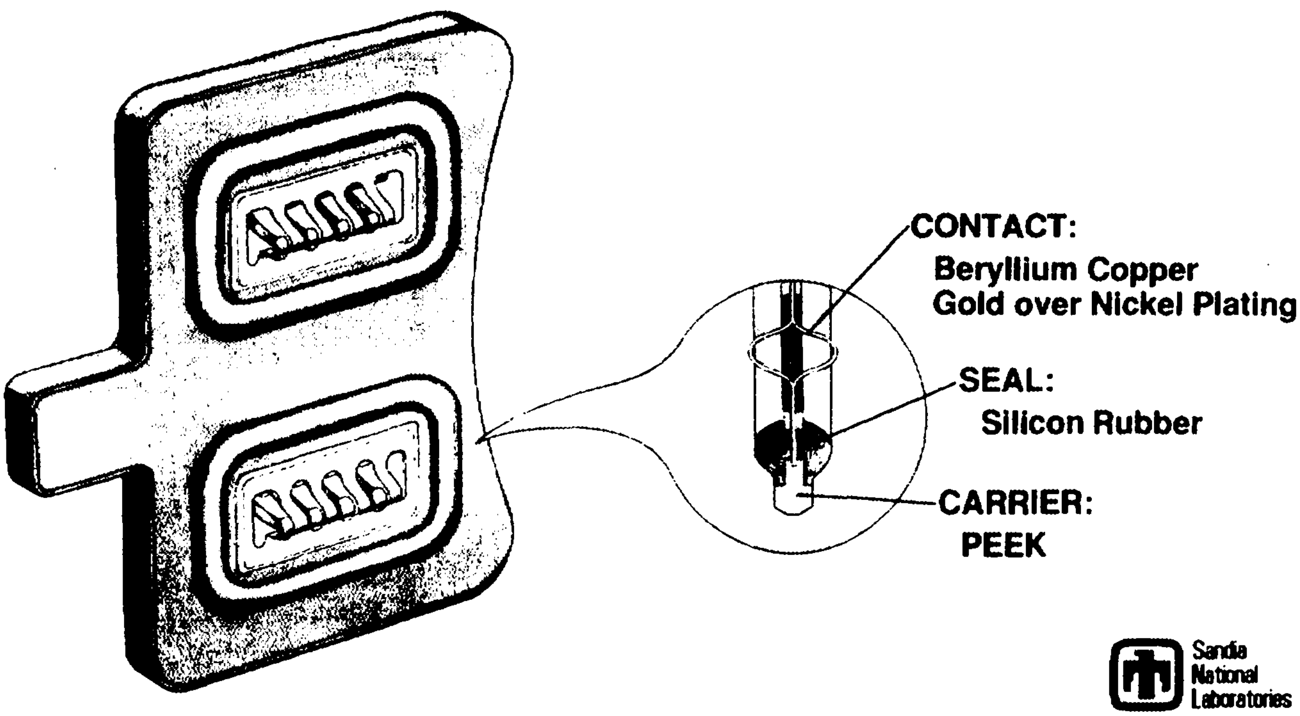

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Figure 5. NG Contact and Seal Assembly

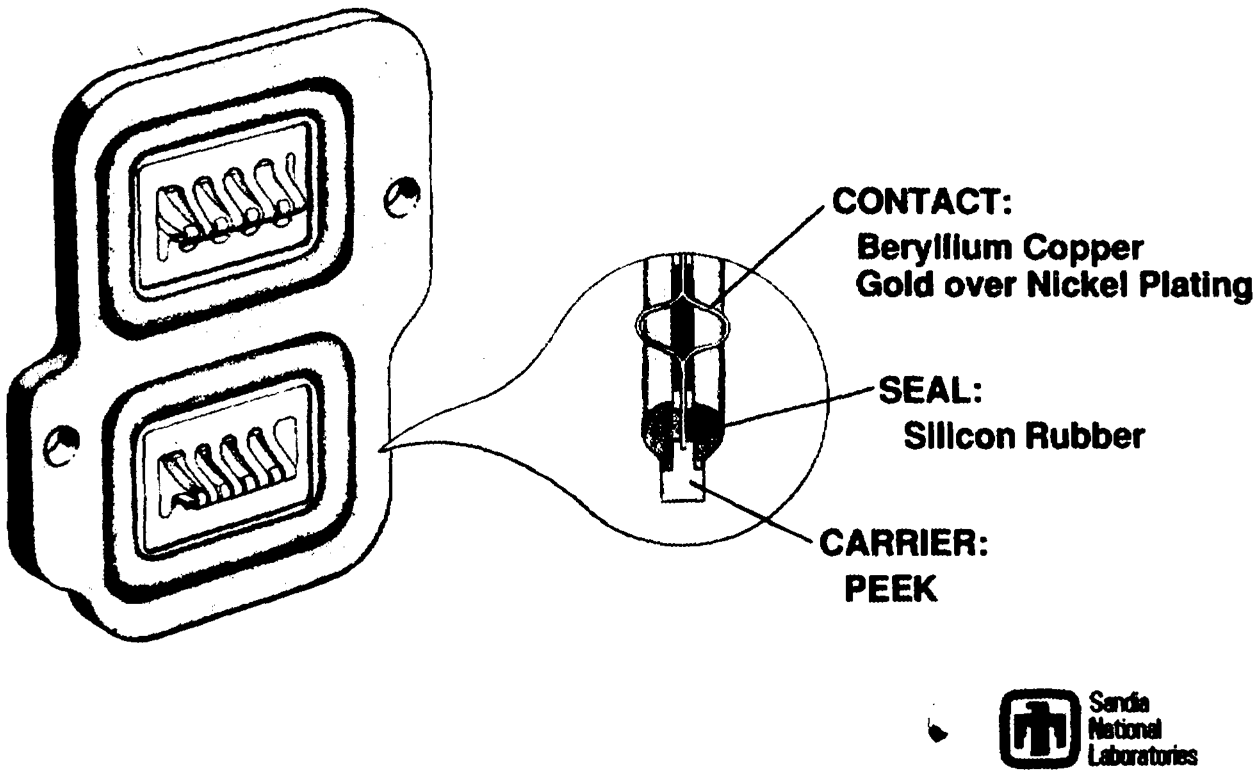


Figure 6. Series Contact and Seal Assembly

Table 1. HVLI Development Testing (PO 63-5160)

Test	Description
Insulation Resistance Altitude	10 kVdc at 2.5 torr 10-microamp maximum leakage
Contact Resistance	3.0 milliohms at 1.0 amp
Accelerated Life	−55 to 160°F, 100 cycles −65 to 180°F, 1 cycle
Temperature Shock	−65 to 25°C, 2 minutes maximum 25 to 135°C, 2-minute ramp, 30-minute dwell
Temperature Cycle	−65 to 135°C, 30-minute ramp, 30-minute dwell, 10 cycles
Temperature Step	25 to −65°C, 55 to −65°C, 1-hr dwell, 1-hr ramp
Mechanical Shock	2,000 g, 2.0 millisec
Random Vibration	1.0 g^2/Hz, 20 to 2,000 Hz, 1.5 minutes per axis

Note: 1. Monitor for open circuits during all environmental tests.
2. Insulation resistance and contact resistance are determined before and after all tests.

Table 2. HVLI Test Summary

Contact	Test Results
Solid	2 vibration units failed post-test hi-pot: 1 foreign material found 1 failure through polyimide identified 3 units failed temperature shock post-test circuit resistance Retested and monitored failures: Opened at low temperature Closed at high temperature 3 units failed temperature step test: Opened at low temperature Closed at high temperature
Spring	All units passed shock/vibration/temperature Retested temperature cycle to monitor during test Accelerated life completed; 1 unit post-hi-pot failure
Flat	3 units passed temperature cycle/shock/vibration 3 units passed each test, 3 units passed all tests
Solid Contact with Cellular Silicone	1 unit passed temperature cycle; 1 failed (insufficient compression) 3 units passed temperature cycle; 1 opened at room temperature

Requirements, Responsibilities, and Testing

Specification CD456024 states the requirements for the CSA. To coordinate the design information among all of the laboratory organizations affected by the HVLI interconnect effort, the Electrical Interconnections and Computer Support Department generated three SSs. Specifications SS388316, SS388317, and SS390412 (Appendix A) control the critical hardware design features used in the CSA project. These documents require joint signoff by the SNL PRESS Mechanical and Electrical Systems Departments, the Firing Set and Mechanical Design Department, the Explosive Components Department, the Electrical Interconnections and Computer Support Department, and the LLNL/L125 Systems group. The responsibilities of each group are as follows:

- The Firing Set and Mechanical Design Department is responsible for the dimensions of the pocket and compression lids that contain the Main and NG CSA and for the Main CDU and NG CDU cables. (These parts are part of the MC4069 Firing Set definition.)
- The Explosive Components Department is responsible for the NG cable that goes into the NG timer.
- LLNL is responsible for the detonator cables that interface with the MC4069.
- The PRESS Mechnical and Electrical Systems Departments at SNL/California have overall responsibility for the system, and for the pocket in the deck plate and compression lid that contains the LLNL cables and the Series CSA.

Table 3 compares CD requirements to the development testing that was performed. Whenever possible, development testing verified that the CSA met the CD requirements. For the CSA final acceptance, only electrical testing will be required. Other acceptance tests were required for the CSA, but functional requirements were checked at each piece-part level. For each applicable AY drawing, we will measure the important properties. Data that we collected on early production parts will be used as acceptance criteria for individual parts. Most of the data were based on a sample of the development lot for each part or on a sample of the material used to make the lot; therefore, the properties of the parts that were tested for development testing can be related to parts that will be fabricated later. At final acceptance, we will check the spring contacts for force versus deflection, and for set and final height. Silicone rubber seals will be checked for overall height and compression set. At final assembly, we will check insulation resistance at low pressure.

Damage Assembly Prevention

Because of concerns that damage to the spring contacts could occur when assembling the system, LLNL proposed a new design concept, and Sandia's Electrical Interconnections and Computer Support Department developed it into the CSA. The design used the same spring contacts as the previous design but removed the contacts from the cables and captured them in a separate, removable carrier. Thus, the impact of damage to the spring was reduced because the entire assembly could be replaced. The three applications for the final design concept are shown in Figures 4 through 6.

Table 3. HVLI CD Requirements vs. Development Tests

Description	CD Requirement	Development Test
Temperature	−50 to 155°F	−55 to 160°F, 100 cycles
Mechanical Shock	250 g, 5 ms	2,000 g, 2.0 ms
Random Vibration	1.015 g^2/Hz max	1.0 g^2/Hz, 20 to 2,000 Hz
Acceleration	+20 g	NA[1]
Voltage	5 kv, 200 ns	10 kVdc, 1.0 A
Current	6 kA	6 kA
Inductance (max.)	5 nH	4.6 nH[2]
Insultation Resistance	100 Mohms	1,000 Mohms
Contact Resistance (max.)	5.0 mohms	3.0 mohms[3]
Durability	50 cycles	NC[3]
Pressure	0.2 torr	2.5 torr

[1]NA = test not planned
[2]Lab measurements, one unit
[3]NC = test not complete

Dielectric Rubber Seal Tests

The CSA provides a dielectric seal by compressing a silicone rubber rib molded around the contacts onto either side of a polyetheretherketone (PEEK) carrier. This rubber is trapped between two flexible flat cables inside of a pocket.

To prevent electrical breakdown, the force of the rubber against the flat cables must be tightly controlled. To control this force, we had to control the maximum compressed height (minimum compression) of the rubber. However, the rubber was susceptible to relaxation if we compressed it too far (maximum compression). Appendix B describes the calculations we made on the compressed height of the three designs (Main, NG, and Series).

Alignment of the CSA relative to the other parts in an HVLI connection is controlled by the edges of a pocket that contains it. This alignment is critical if the dielectric seal is to be maintained. Appendix B contains the dimensions and tolerances related to movement in the plane of the CSA. Because of the way flat flex cables are fabricated, only one surface is flat; the other surface varies in height as layers are added or dropped. Also, to make electrical contact to the copper, the outer coating is exposed. When trying to control the compression of the dielectric seal, these changes in height become a problem. Each cable contains a flat area for sealing, which is located between the edge of the window cutout (for contact) and the edge of the copper layer under the outer coat. The edge of the contact window is far enough away from the seal that it is not a concern, but the dielectric seal is near the edge of the copper, which ends approximately 0.070 inch from the outside edge of the cable. If the centerline of the dielectric seal went beyond the edge of the copper, compression would begin to drop off quickly, possibly leading to voltage breakdown.

To provide a barrier to current flow, the silicone rubber seal must be compressed. Establishing the minimum amount of compression needed for a given voltage and pressure was complicated. After the Series CSA units failed at Allied Signal, we assembled several Main CSAs with shims to vary the compression. Results of the insulation resistance tests at reduced pressures on these units were erratic. The Series units that failed had compression of around 0.012 inch. Main CSAs assembled with 0.016 to 0.020 inch of compression showed some success at 6.0 kVdc but failed because of test cables or foreign material. All of the CSAs had 0.065 inch of free height of rubber, and if the minimum compression needed was 0.020 inch, the maximum allowable compressed height of rubber would have been 0.045 inch. Figure 7 shows the force that was needed to compress both of the seals on the Series CSA. The three curves grouped together show the tests we ran at up to 500 lb, then back to zero. At 0.045 inch, the pressure was about 20 lb. On all three CSAs, compression values varied (from 0.006 to 0.046 inch) with assembly tolerances. A compression of 0.006 inch from nominal would show a compressed height of 0.054 inch and only about 5 lb of force. This condition has not been a problem because not all parts are being manufactured at the minimum height. Therefore, we believe that an increase in the free height of the rubber would solve this problem without changing any tolerances, but the increase would generate a force of more than 1,000 lb at the other tolerance extreme.

Silicone Rubber Material Selection

Early in the program, we began screening to identify the best formulation for the HVLI connection. Initial candidates were selected based on advertised compression set values and history that Allied Signal used. Figure 8 shows the results of the preliminary testing. Appendix 6 is a copy of the test report from Mark Wilson, D/837, at Allied Signal. From the data in Figure 8, formulations DC747, SE6180, and SE3723 were chosen as likely materials for this application. In the HVLI design, the force remaining at the end of life was the most important property and provided the best seal, even if there was a large decrease from the initial value. After we completed the initial screening, DC747 became the baseline formulation because Allied Signal was already using it. SE6180 and SE3723 were also promising candidates.

Appendix C contains other silicone rubber information. These references have general properties data for finite element modeling (FEM) analysis and water absorption.

Spring Contact Tests

To make electrical contact from one flat cable to the other, two spring contacts, welded together, touched each flat cable. Once the springs were welded, they were molded into the PEEK carrier. The surfaces of the flat cable and the spring contact were gold plated with a nickel flash underneath. Berylium copper, 0.003 inch thick, was used to fabricate the springs.

The contact fingers had to provide enough force to make a low-resistance joint but not take a permanent set at tolerance extremes. Figure 9 shows force versus deflection curves for a single spring finger. Although the fingers on the CSA were 0.003 inch thick and 0.090 inch wide, measured values were below those predicted by M. K. Neilson of the Engineering Mechanics and Material Model Department. The curve of the 0.004-inch-thick finger was closer to those measured, perhaps because of the plating on the outside of the tested contact. From the dimensional studies in Appendix B, we see that the range of deflection on the CSA was 0.016 to 0.059 inch. Because two springs were back to back, the deflection on a finger went from 0.008 to 0.029 inch. The curves indicate that if a contact saw a 0.030-inch deflection, it would suffer a permanent set of 0.008 inch. This condition is not a problem because the CSA is replaceable and the deflection does not change once assembled. By changing the length and thickness of the finger, the CSA could be designed to take this full range of deflection without having a permanent set; however, room is not available in the W89 to do this.

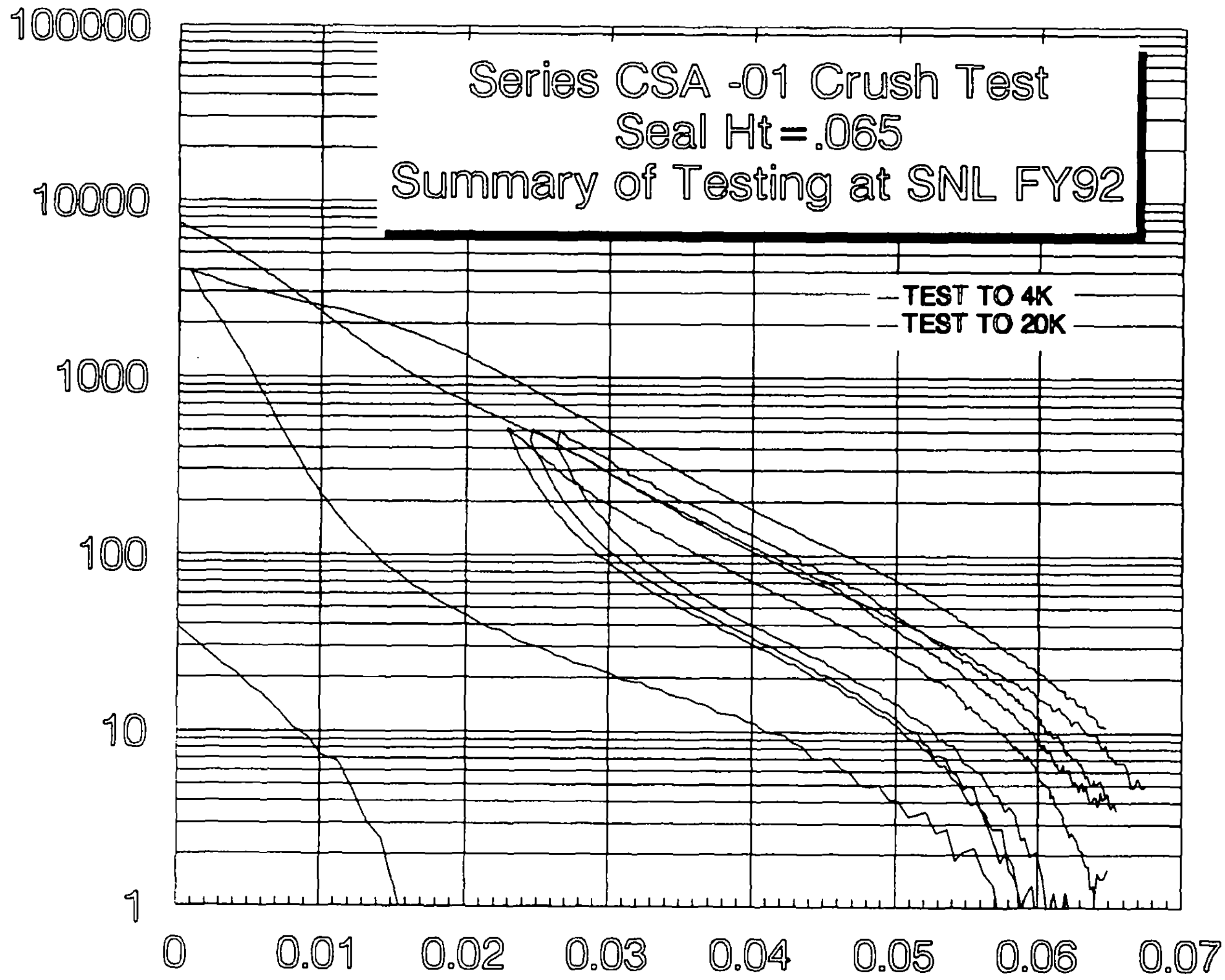
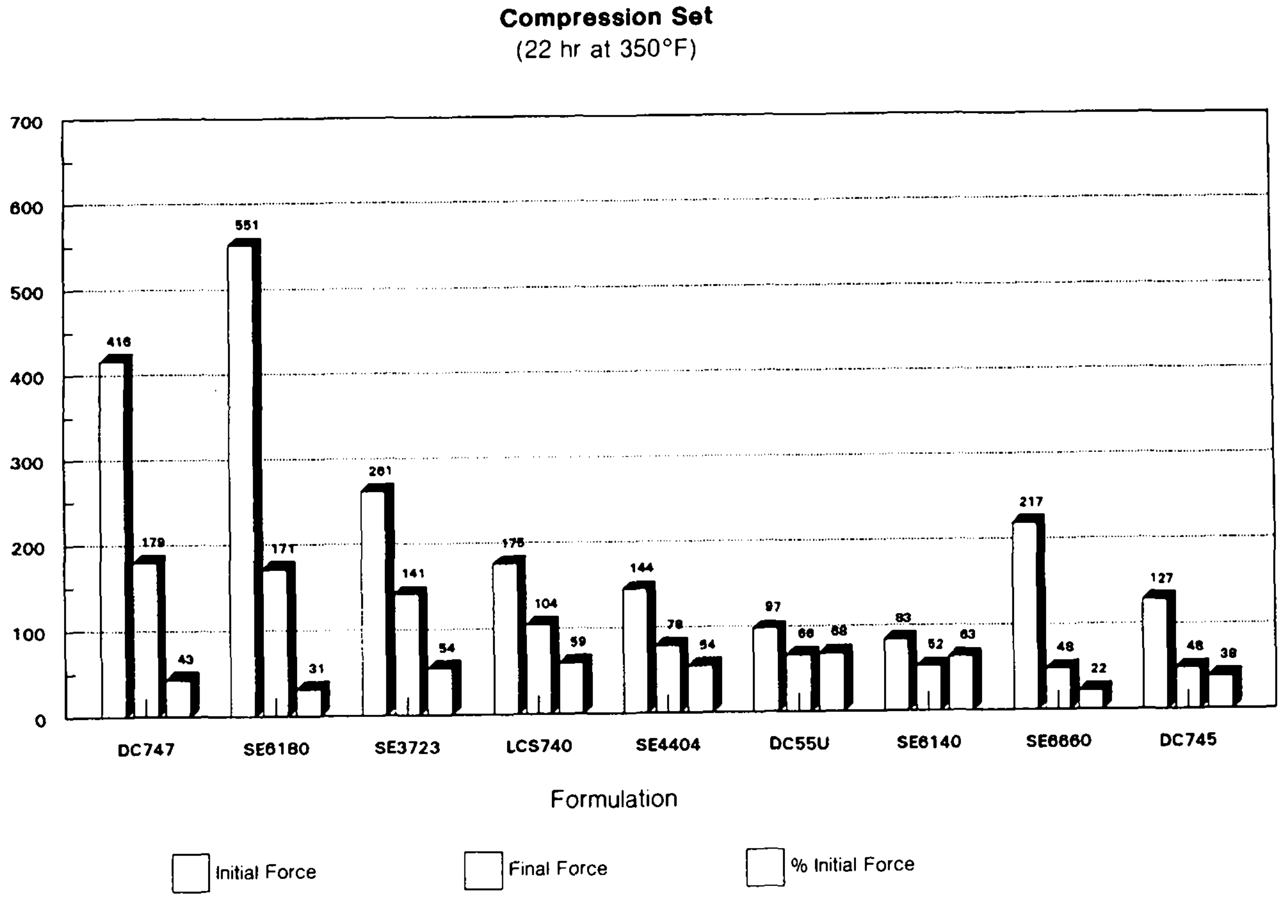


Figure 7. Series CSA Crush Test



1. Candidate materials for W89 HLVI gaskets
2. Data from M. Wilson, KCD

Figure 8. Preliminary Test Results of Various Formulations

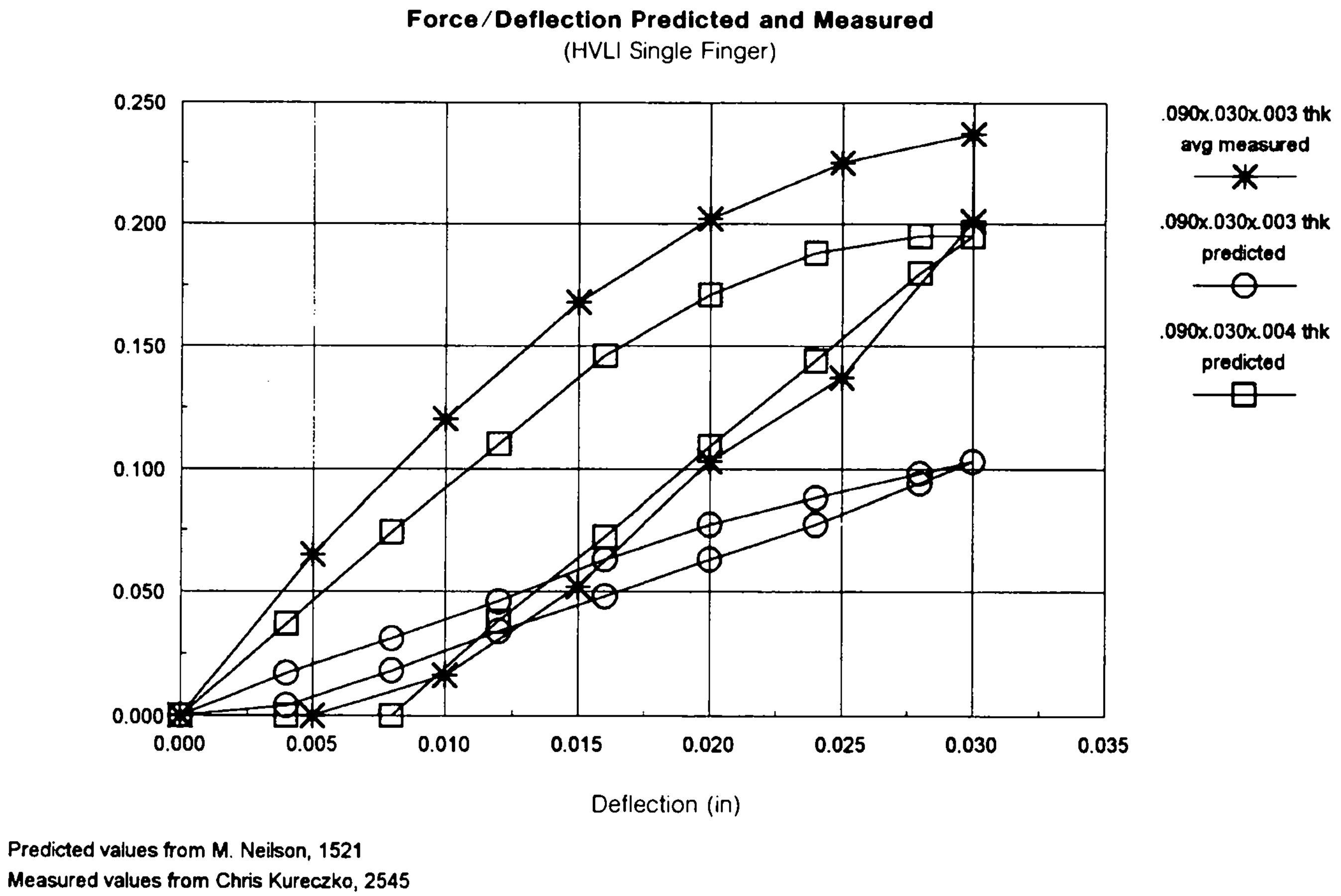


Figure 9. Force/Deflection Predicted and Measured (HVLI single finger)

CSA Development Testing

The first testing performed on the CSA design concept occurred in May 1989 using six Series CSAs fabricated from machined ULTEM carriers, RTV rubber seals, and spring contacts bonded in place. The test series, which was the same as previous units, included temperature cycle, random vibration, and mechanical shock. Results were favorable when we checked insulation resistance at low pressure before and after testing. Of the six units started, we attributed only one failure to the CSA; the flex cables caused the other failures. (Results are documented in Appendix D.)

Contract 63-5160 was amended to define the evaluation of the CSAs. Appendix D contains the description of that testing. Phases 1 through 4 were early versions of the HVLI. Phase five tests used only Main CSAs; phase six tests used Main, NG, and Series.

Phase five tested six units that had carriers machined from PEEK and seals that had been molded in place at Stillman Seal in Carlsbad, California. After the seals were molded on, spring contacts were bonded in place on the carrier. Allied Signal fabricated six more Main CSA units. These units duplicated the final design, except the spring contact contained a large flange area that extended under the dielectric seal. We later modified this flange area to prevent potential breakdown if the bond between the seal and the carrier broke. Screws that loosened in the mounting block (the only failure noted) were tightened and retested.

Low-temperature testing (−65°F) was performed on one of the Allied Signal units that had been exposed to all four environmental tests. We placed this unit in a large fixture (to provide a heat sink) and soaked it to a temperature below −65°F. Insulation resistance was then checked at 6 kVdc and 0.5 torr. No failure occurred.

As part of the MC4069 Firing Set study to change solvents, we exposed several Main CSAs to d-limonene and evaluated them. These units were assembled into mounting blocks and subjected to a thermal cycle in a d-limonene atmosphere followed by an insulation resistance test. No failures were noted that could be attributed to the CSA.

Phase six tested the final configuration of all three designs. Because of program uncertainties and the loss of key personnel at Allied Signal, some of the test results are not clear. Main CSAs performed well with no known failures. NG CSAs had two failures when final insulation resistance was performed. We did not test the Series CSAs because of insulation resistance failures at the first assembly point. We attributed these failures to low compression of the dielectric seal, and determined that an increase in seal thickness would be needed; however, no change was made to the tooling.

Conclusion

The development of the W89 high-voltage, low-inductance interconnect was successful. Future work will include increasing the design margin for minimum compression of the silicone rubber seal.

APPENDIX A

Specifications

1. GENERAL

1.1 Scope

This document defines the characteristics of the High Voltage Low Inductance (HVLI) Interfaces in the W89 Electrical System that are subject to special controls to preserve interface compatibility. This document shall not be used as manufacturing or acceptance criteria. The approved product definition will be consistent with the characteristics stated herein.

1.2 Description

This document describes the three High Voltage Low Inductance Interfaces in the W89. They are:

a. Main HVLI Interface. This is the interface between the MC4069 Firing Set and the LLNL Slapper Cable, Short.

b. NG HVLI Interface. This is the electrical interface between the MC4069 Firing Set and the MC4135 Neutron Generator Assembly.

c. Series Connection HVLI Interface. This Interface connects the two LLNL Slapper cables in series electrically.

1.3 Change Control

This document cannot be changed without the approval of the Interconnections Development Department (2251) the PRESS Electrical Systems Department (5355), the Firing Set and Mechanical Design Department (2364), and the Detonating Components Department (2513).

1.4 Reliability

These interconnections shall function during and after exposure to all normal environments specified in SB210447 with a reliability of 0.99998. It is understood that it is not practical to demonstrate a failure probability this small on a single device type. However, all test data shall be consistent with a 0.99998 reliability.

2. DOCUMENTS

2.1 Required Documents

SB210447	W89 Component Environments
SB393185	MC4069 Environmental Requirements

2.2 Reference Documents

CD411383	Control Drawing, MC4069 Firing Set
SB455986	Interface Drawing, MC4069 Firing Set
CD411618	Control Drawing, MC4135 Neutron Generator Assembly
SB455987	Envelope Drawing, MC4135 Neutron Generator Assembly
SS388316	HVLI Interface, Main
SS388317	HVLI Interface, NG
SS338318	HVLI Interface, Series
SB393185	MC4069 Processing
AY455487	Deck, Firing Set

3. ENVIRONMENTS

3.1 Normal Environments

The normal environments through which these interconnections must operate are defined in SB210447. They are specified differently for forward and aft components. The interfaces are required to meet the forward component environments. In addition, during processing at KCP, the MC4069 Firing Set will be subjected to various cleaning and thermal environments, as defined in SB393185. These are considered non-degrading environments.

3.2 Abnormal Environments

There are no abnormal environment requirements for these interfaces.

4. MECHANICAL REQUIREMENTS

4.1 Contact Plating

The electrical contacts must be gold plated to prevent corrosion.

4.2 Inspection

Each of these interconnections must have a design feature that allows a single visual inspection to verify that all the elements were installed in the proper order.

4.3 Durability

Each of these interconnections shall be capable of 50 mate/demate cycles during its life without suffering a degradation in performance or reliability.

5. ELECTRICAL REQUIREMENTS

5.1 Main

Maximum Charge Voltage ...... (see Figure 1)
Maximum Current .... (see Figure 1)
Duration .... (see Figure 1)
Frequency Range .... dc to 3.0 MHz
Resistance
Contacts .... ≤ 5.0 mΩ each conductor @ 1 A dc
Insulation .... > 100 MΩ @ 5 kV peak pulse
Minimum Standoff Voltage ..... 7500 V dc
Inductance .... < 5.0 nH @ 3 MHz
Number of Pulses .... ≥ 75

5.2 NG

Maximum Charge Voltage ...... (see Figure 2)
Maximum Current .... (see Figure 2)
Duration .... (see Figure 2)
Frequency .... dc to 3.0 MHz
Resistance
..... Contacts .... ≤ 5.0 mΩ each conductor @ 1 A dc
..... Insulation .... >100 MΩ @ 3.25 kV peak pulse
Minimum Standoff Voltage ..... 5000 V dc
Inductance .... < 5.0 nH @ 3 MHz
Number of Pulses .... ≥ 75

5.3 Series Connection

Maximum Voltage .... (see Figure 1)
Maximum Current .... (see Figure 1)
Duration .... (see Figure 1)
Frequency range .... dc to 3.0 MHz
Resistance
Contacts .... ≤ 5.0 mΩ each conductor @ 1 A dc
Insulation .... > 100 MΩ @ 5 kV peak pulse
Minimum Standoff Voltage ..... 7500 V dc
Inductance .... < 5.0 mH @ 3 MHz
Number of Pulses .... ≥ 75

6. HAZARDOUS MATERIALS

As a goal, use of toxic and/or hazardous materials in this component or its fabrication processes should be minimized. All toxic and/or hazardous materials and their quantities used in this component or its fabrication processes shall be noted and recorded.

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MAIN CONNECTION, W89 (U)

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1. GENERAL

1.1 Scope: This document defines the electrical connection between the cables of the MC4069 Firing Set Main Capacitive Discharge Unit (CDU) and the Main Detonators.

1.2 Description: This connection consists of flat flex Cable S (figure 2) and the Main CDU cable (figure 1) terminated at the Mounting Block (figure 3) located on the side of the MC4069. The cables are positioned by the mounting block such that the contact areas on each circuit line up and face the corresponding circuit on the opposing cable. A Compression Lid (figure 4) holds the assembly together inside the Mounting Block by applying pressure to the back of Cable S. The silicone rubber in the Contact/Seal Assembly (figure 6) prevents electrical breakdown between each of the circuits as well as between the circuits and the Mounting Block. Spring contacts (Fig. 5), molded into the Contact/Seal Assembly provide electrical contact between the two mating cables.

1.3 Control. Initial release and subsequent changes to this document require approval of the supervisors and engineers of the following organizations: 8155, 2364, L125, 2551, and 2833.

2. DOCUMENTS AND EQUIPMENT

The following documents and equipment form a part of this specification to the extent stated herein.

SB210447	W89 Component Environments
CD384899	Compatibility, Main Detonator Interface/MC4069
385512	Mounting Block, Main
385517	Lid, Compression, Main
386854	Cable, Main CDU
256081	Cable S
SS379420	Flexible Printed Wiring Product Requirements
393049	Contact, Spring, HVLI Assembly
9902112	Gold Plate, Electrodeposited
9902105	Nickel Plate, Electrodeposited
SS391425	Rubber, Silicone Gasket Material
2221007	Molding Compound, PEEK D150GL30
2323952	Cover Coat, Polyimide
2332722	Copper Clad
QQ-N-290	Nickel Plating, Electrodeposited
MIL-G-45204	Gold Plating, Electrodeposited
2181044	Adhesive
2322952	Cover Coat
2330722	Copper Clad
392920	Contact and Seal Assembly, Main

3. MAIN CDU CABLE

3.1 Materials: The following is a list of materials to be used in fabrication of the flex circuits for the Main CDU cable.

2181044	Adhesive .002
2322952	Polyimid .002/Adhesive .002
2330722	Polyimid .002/Copper Clad 2 oz.

3.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches thick per QQ-N-290, followed by electrodeposited gold .0001 minimum thick per MIL-G-45204, Type II, Grade C.

3.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

3.3 Dimensions: Figure 1 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 1. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

4. CABLE S

4.1 Materials: The following is a list of materials to be used for fabrication.

2181044	Adhesive .002
2323952	Polyimid .002/Adhesive .002
2332722	Polyimid .002/Copper Clad 2 oz.

4.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches thick per QQ–N–290, followed by electrodeposited gold .0001 minimum thick per MIL–G–45204, Type II, Grade C.

4.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

4.3 Dimensions: Figure 2 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 2. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

5. MOUNTING BLOCK

5.1 Material: Corrosion resistant steel, per 7341020.

5.2 Finish: Passivate per 9904301.

5.3 Dimensions: Figure 3 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 3. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

6. COMPRESSION LID

6.1 Material: Corrosion resistant steel per 7341000.

6.2 Finish: Passivate per 9904301.

6.3 Dimensions: Figure 4 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 4. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

7. SPRING CONTACT

7.1 Material: Beryllium Copper per 7513015. Heat treat for 2 to 2.5 hours at 650 to 675°F.

7.2 Plating. The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches thick per 9902105, followed by electrodeposited gold .0001 minimum inches thick per 9902112, Type I.

7.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

7.3 Dimensions: Figure 5 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 5. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

8. CONTACT AND SEAL ASSEMBLY, MAIN

8.1 Fabricate and Inspect silicone rubber seal per SS391425.

8.2 Fabricate carrier portion of assembly from PEEK per 2221007.

8.3 Dimensions: Figure 6 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 6. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

9. ASSEMBLY

9.1 Handling: Finger cots or lint free gloves shall be worn during the assembly operation.

9.2 Parts shall be free of foreign material and other contaminants. All cleaning shall be done per SNL approved procedure.

9.3 Assembly Procedure:

a. Place Contact/Seal onto Main CDU Cable and check for proper alignment.

b. Bring Cable S into position taking care not to disturb the Contact/Seal alignment. Hold in place.

c. Place Compression Lid on top and align holes with the Mounting Block holes. Start 2 of the screws at opposite corners of the assembly.

d. Tighten screws lightly down to Compression Lid.

e. Start 2 remaining screws and tighten lightly onto Lid.

f. Continue tightening screws, approximately 1 turn at a time, alternating diagonally across the pattern.

g. Torque each screw to 8 ±0.25 in–lb.

h. Verify the proper assembly by looking through the opening in the Main Compression Lid. The Cable S should be visible on top of the Contact/Seal. If either of the parts is not visible, the assembly is wrong.

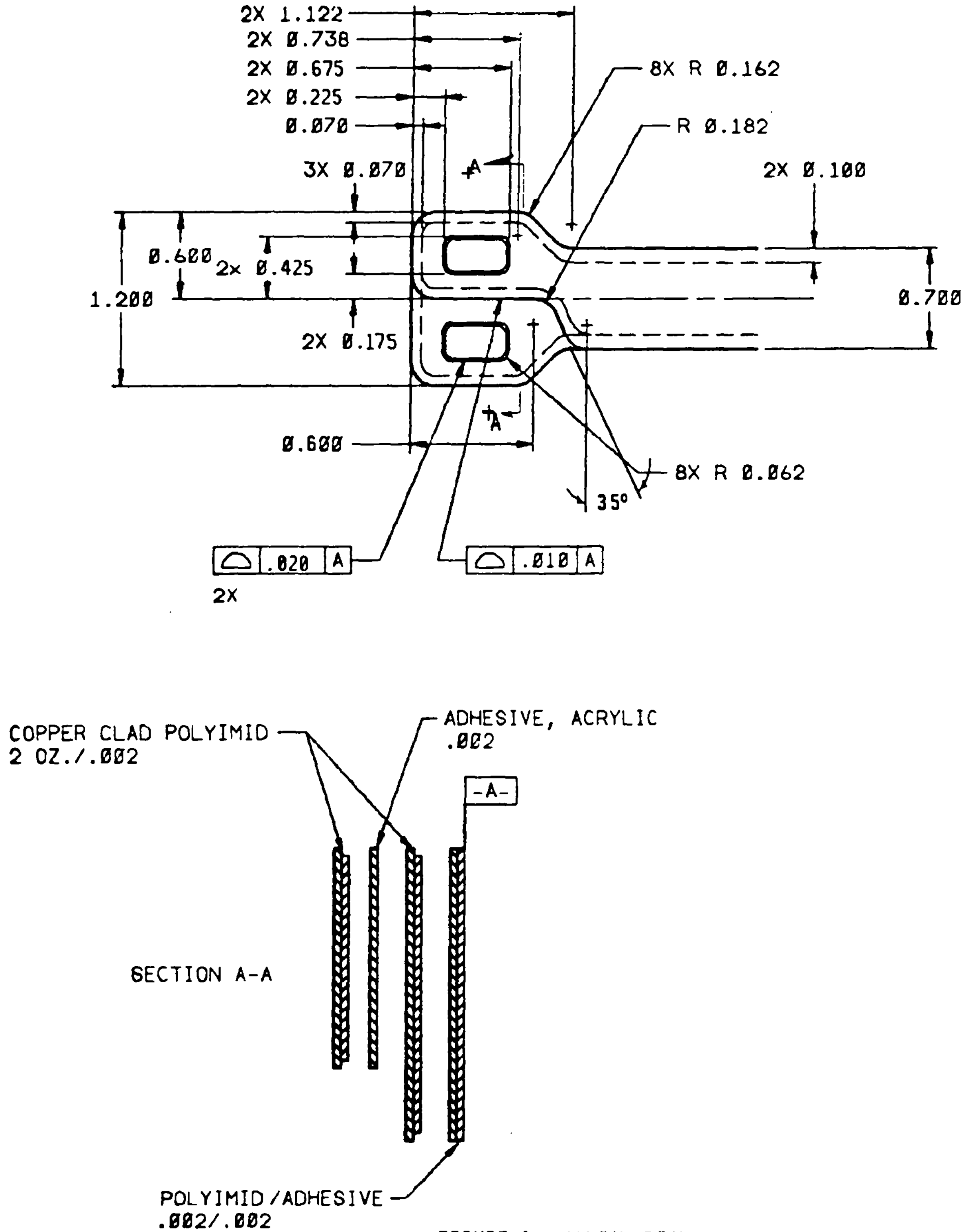
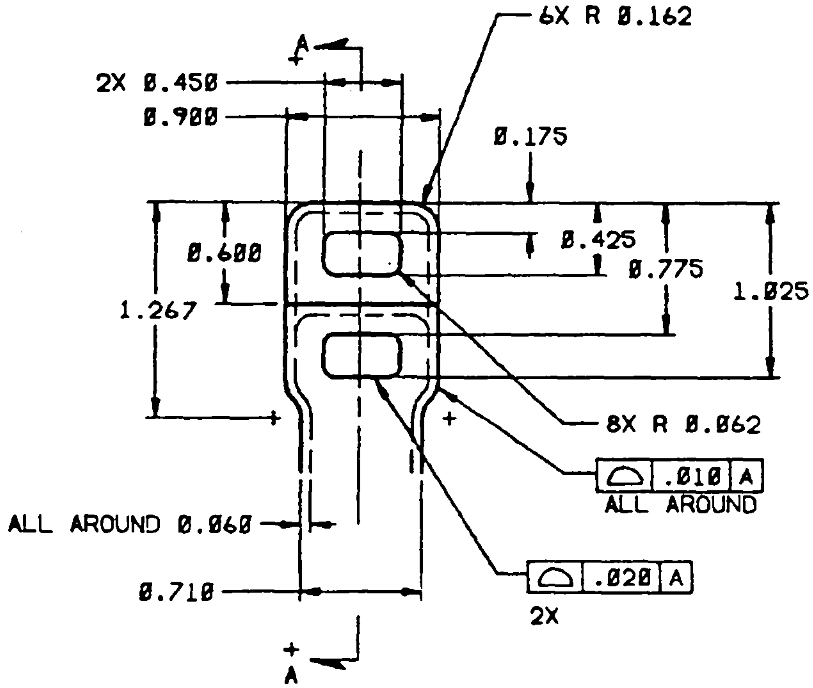


FIGURE 1 - MAIN CDU



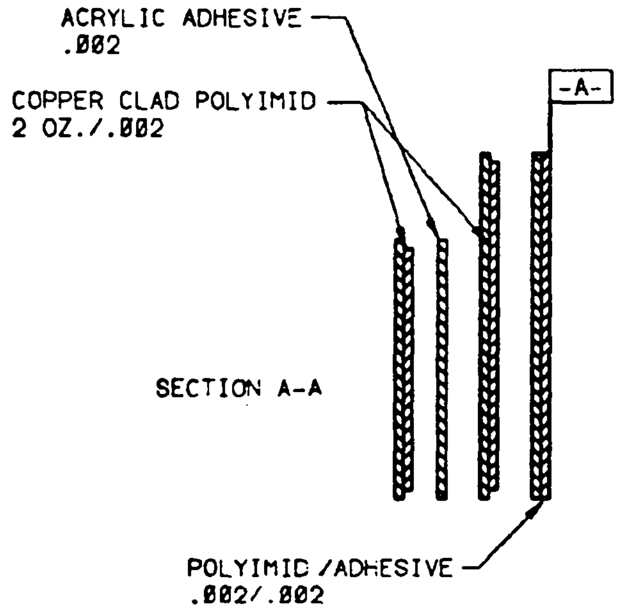


FIGURE 2 - CABLE S

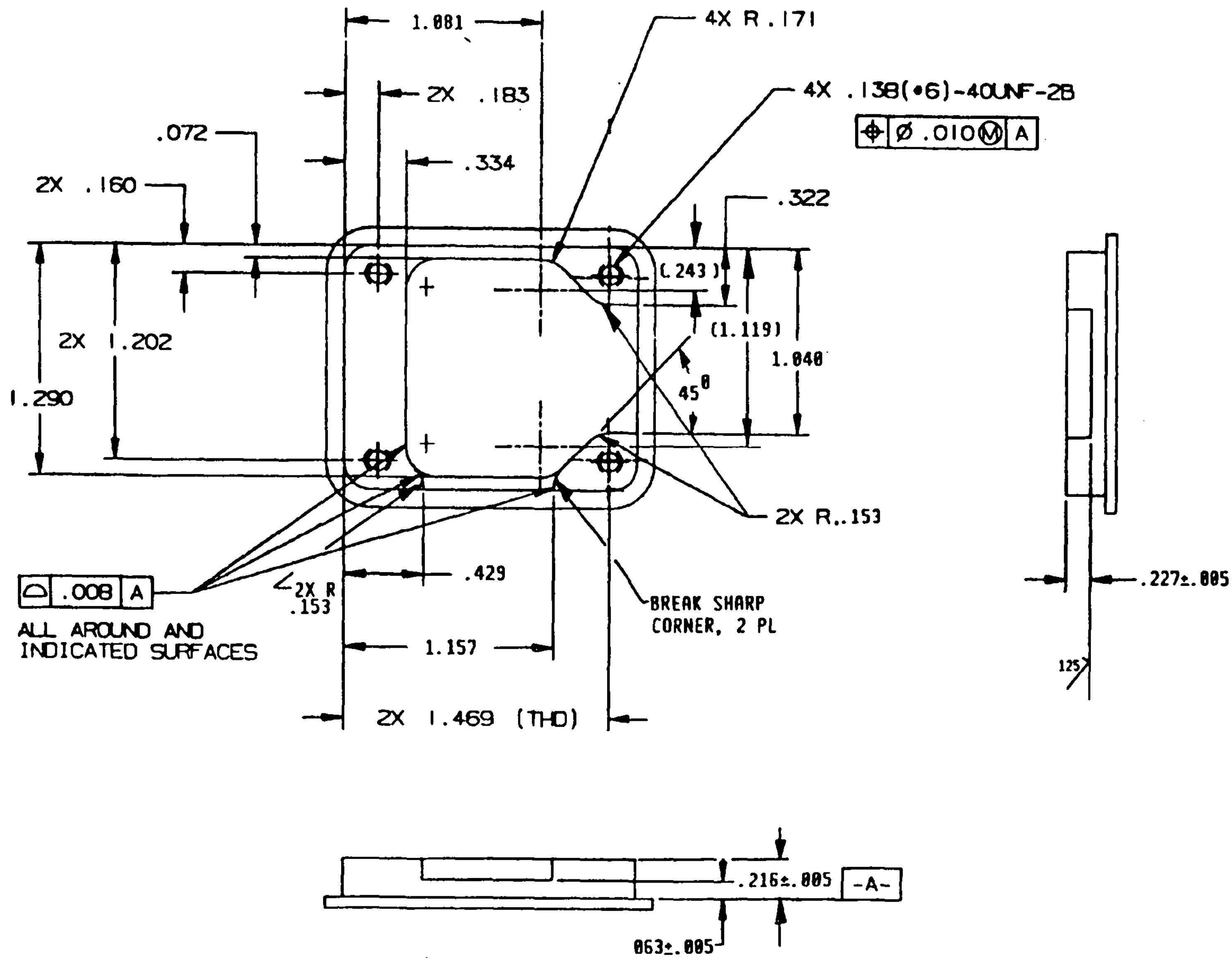


FIGURE 3 - MAIN MOUNTING BLOCK

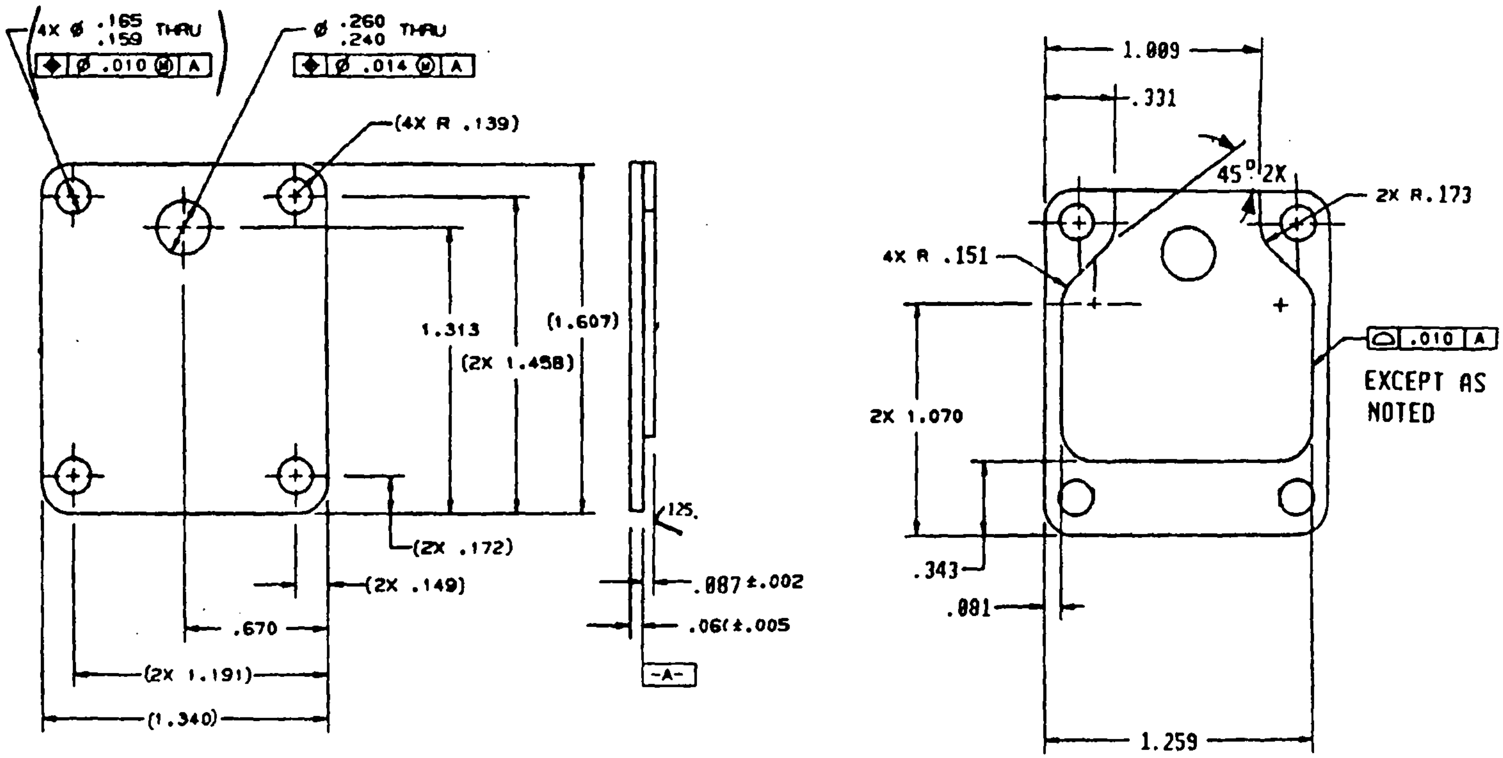
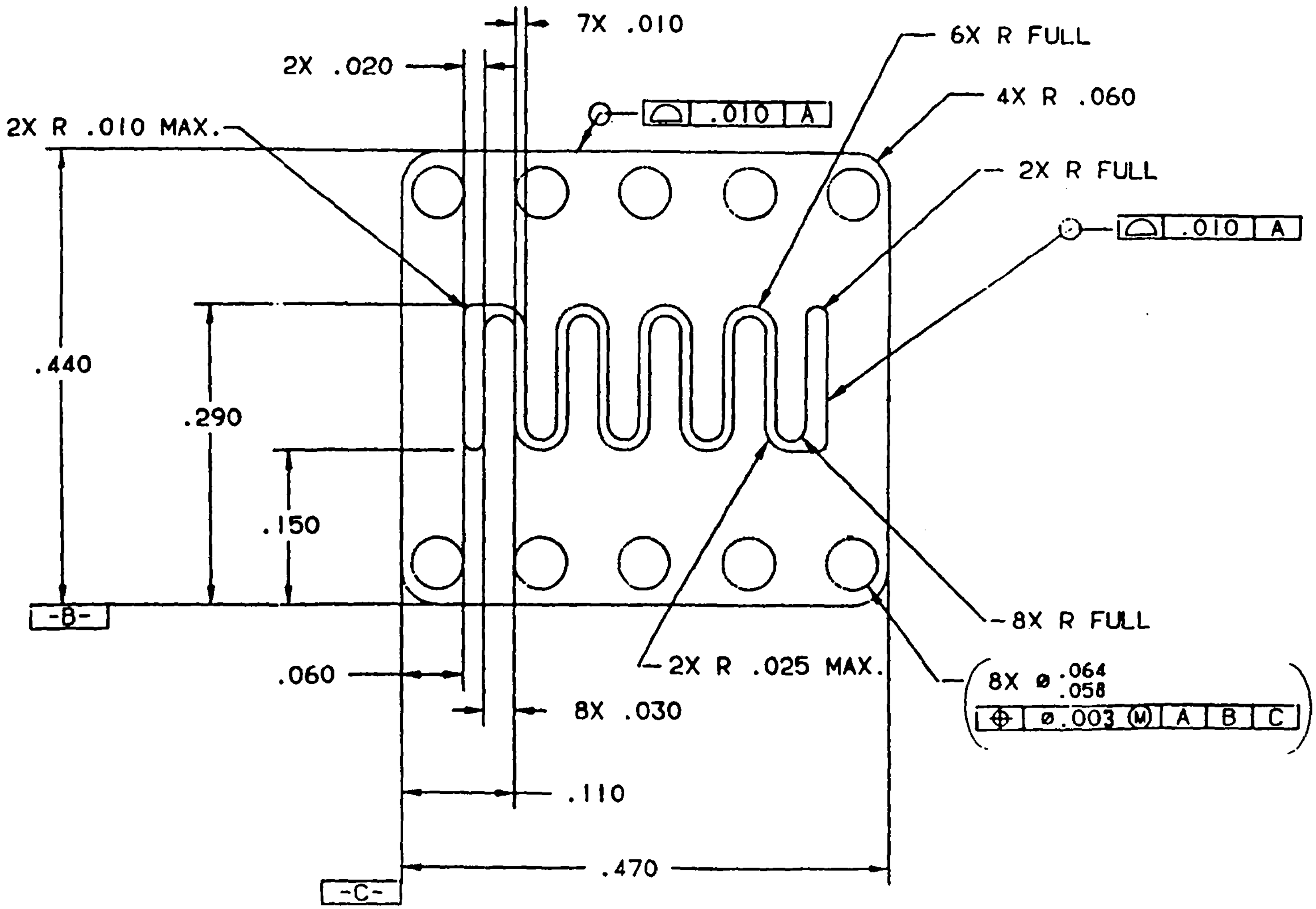
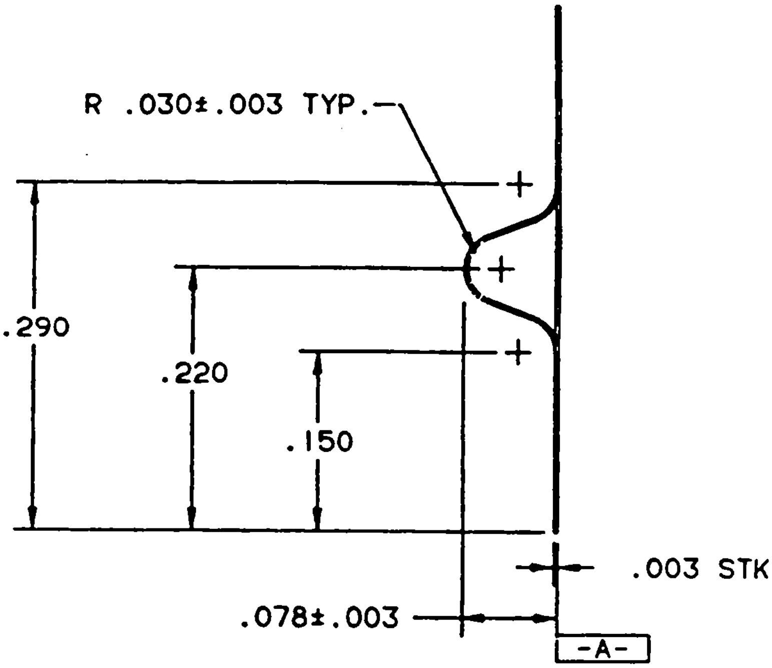


FIGURE 4 - MAIN COMPRESSION LID

FIG. 5A

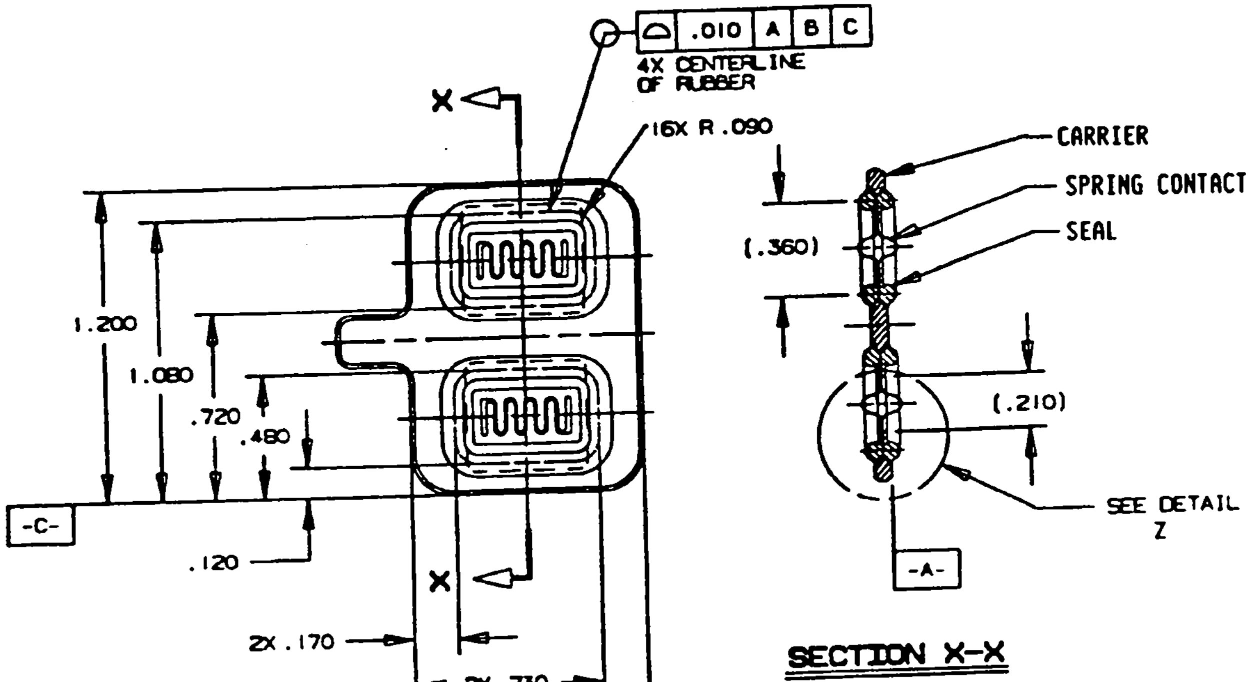


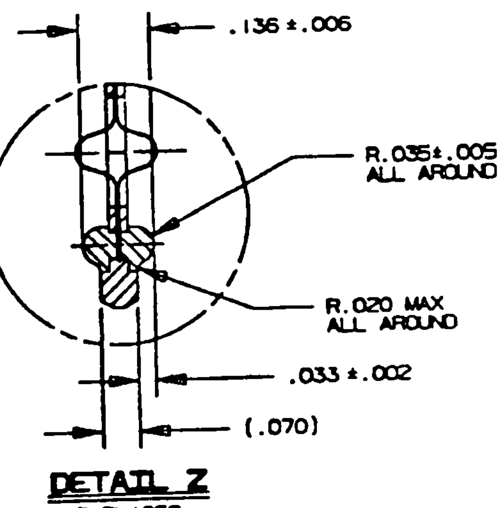
PRIOR TO FORMING



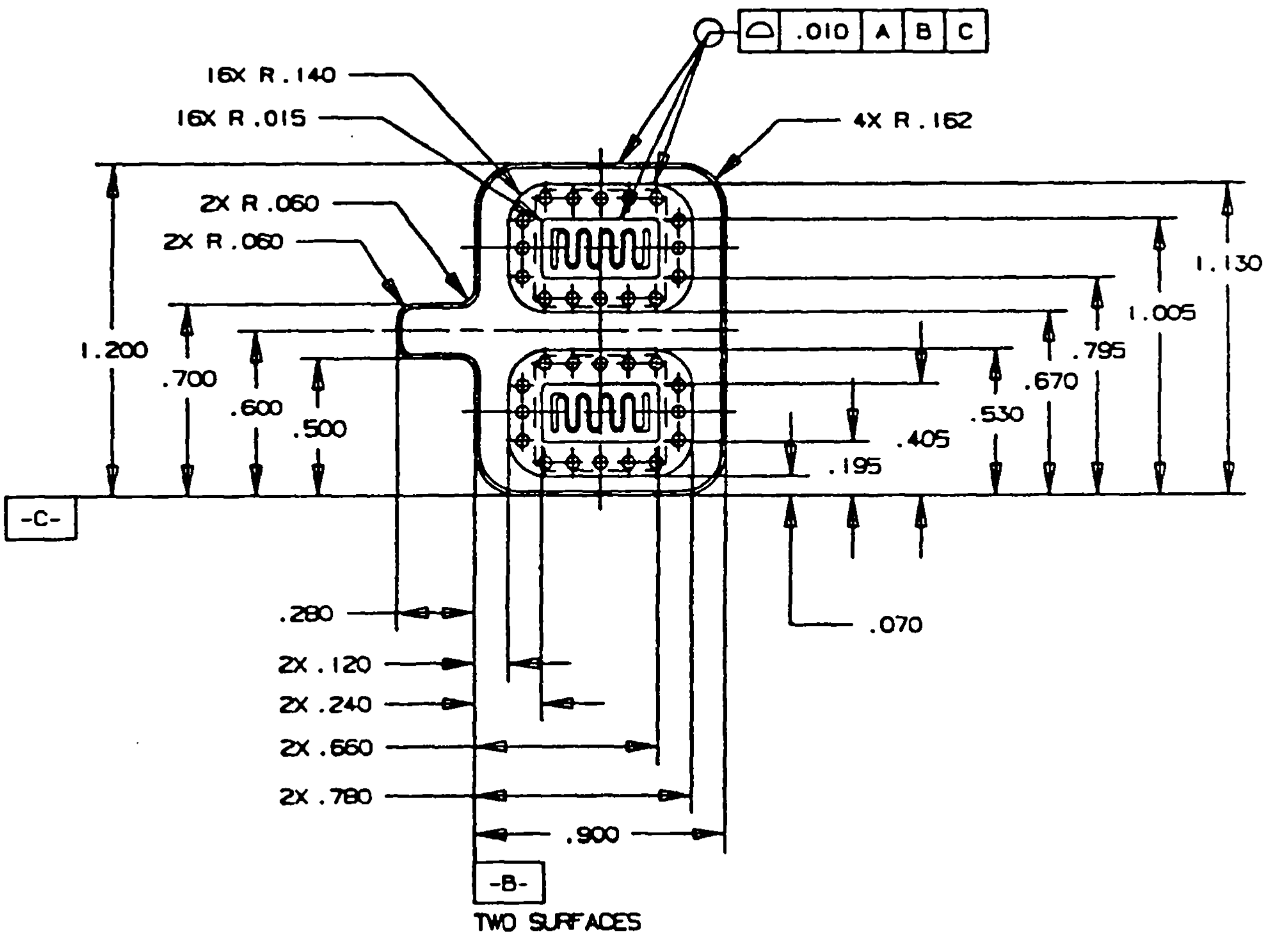
AFTER FORMING

FIG. 5B





MAIN CONTACT/SEAL ASSEMBLY
FIG. 6A



MAIN CONTACT/SEAL SUBASSEMBLY

FIG. 6B

5/7/92

	SUPVR	ENGINEER
8155	J.A. Tilley	R. Sands
2513		S.D. Bamford
2574	J. J. Jones	J. D. Hughes
2551		

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NG CONNECTION, W89 (U)

PAGE	1	2	3	4	5	6	7	8	9	10	11	12	13
ISSUE	D	D	D	D	D	D	D	D	D	D	D	D	D

1. GENERAL

1.1 Scope: This document defines the connection for the Neutron Generator cable to the MC4069 Firing Set.

1.2 Description: This connection consists of a printed circuit cable from the Neutron Generator (figure 2) and one from the Generator Capacitive Discharge Unit (CDU) (figure 1) of the MC4069. These cables are terminated at a Mounting Block (figure 3) located on the side of the MC4069. The cables are positioned such that the contact areas of each circuit line up and face the corresponding circuit on the opposing cable. A Compression Lid (figure 4) holds the assembly together inside the NG Pocket by applying pressure to the back of the NG cable. A silicone rubber seal in the Contact/Seal (figure 6) prevents electrical breakdown between each of the circuits, and between the circuits and the Housing. Spring contacts (Fig. 5) provide electrical contact between the two mating cables.

1.3 Control. Initial release and subsequent changes to this document require approval of the supervisors and engineers of the following organizations: 8155, 2513, 2574, 2551, and 2833.

2. DOCUMENTS AND EQUIPMENT

The following documents and equipment form a part of this specification to the extent stated herein.

SB210447	W89 Component Environments
CD384905	Compatibility, Neutron Generator Detonator Interconnection/MC4069
385016	Housing
385516	Lid, Compression
411562	MC4107
386843	Cable, Neutron Gen CDU
SS379420	Flexible Printed Wiring Product Requirements
IPC–FC–233/4	Adhesive Coated Dielectric Films
393049	Contact Spring, HVLI Assembly
9902112	Gold Plating, Electrodeposited
9902105	Nickel Plating, Electrodeposited
SS391425	Rubber, Silicone Gasket Material
392921	Contact and Seal Assembly, NG
2221007	Molding Compound, PEEK D150GL30

3. GENERATOR CDU CABLE

3.1 Materials: The following is a list of materials to used in fabrication of the flex circuits for the Generator CDU cable.

2181044	Adhesive .002
2181043	Adhesive .001
2322952	Polyimid .002/Adhesive .002
2330722	Polyimid .002/Copper Clad 2 oz.

3.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel per 9902105 .0001 to .0005 inches thick, followed by electrodeposited gold .0001 minimum thick per 9902112, Type II, Class 3.

3.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

3.3 Dimensions: Figure 1 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 1. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

4. NG DETONATOR CABLE

4.1 Materials: The following is a list of materials to used in fabrication of the flex circuits for the NG Detonator cable.

2181044	Adhesive .002
IPC–FC–233/4	Adhesive .001/Polyimid .001/Adhesive .001
2322952	Polyimid .002/Adhesive .002
2330722	Polyimid .002/Copper Clad 2 oz.

4.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches per 9902105, followed by electrodeposited gold .0001 minimum thick per 9902112 Type II, Class 3.

4.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

4.3 Dimensions: Figure 2 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 2. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

5. NG CABLE POCKET

5.1 Material: Corrosion resistant steel, 17–4Ph per 7372174.

5.2 Finish: Passivate per 9904301.

5.3 Dimensions: Figure 3 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 3. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

6. COMPRESSION LID

6.1 Material: Corrosion resistant steel per 7341000.

6.2 Finish: Passivate per 9904301.

6.3 Dimensions: Figure 4 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 4. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

7. SPRING CONTACT

7.1 Material: Beryllium Copper per 7513015. Heat treat for 2 to 2.5 hours at 650 to 675°F.

7.2 Plating. The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches thick per 9902105, followed by electrodeposited gold .0001 minimum inch thick per 9902112, Type II, Class 3.

7.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

7.3 Dimensions: Figure 5 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 5. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

8. CONTACT AND SEAL ASSEMBLY, NG

8.1 Fabricated and inspect Silicone Rubber Seal per SS391425.

8.2 Fabricate carrier portion of assembly from PEEK per 2221007.

8.3 Dimensions: Figure 6 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 6. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

9. ASSEMBLY

9.1 Handling: Finger cots or lint free gloves shall be worn during the assembly operation.

9.2 Parts shall be free of foreign material and other contaminants. All cleaning shall be done per SNL approved procedures.

9.4 Assembly Procedure:

a. Place Contact/Seal onto Generator CDU Cable and check for proper alignment.

b. Bring NG Detonator Cable into position, taking care not to disturb the Contact/Seal alignment. Hold in place.

c. Place Compression Lid on top and align holes with the Mounting Block holes. Start 2 of the screws at opposite corners of the assembly.

d. Tighten screws lightly down to Compression Lid.

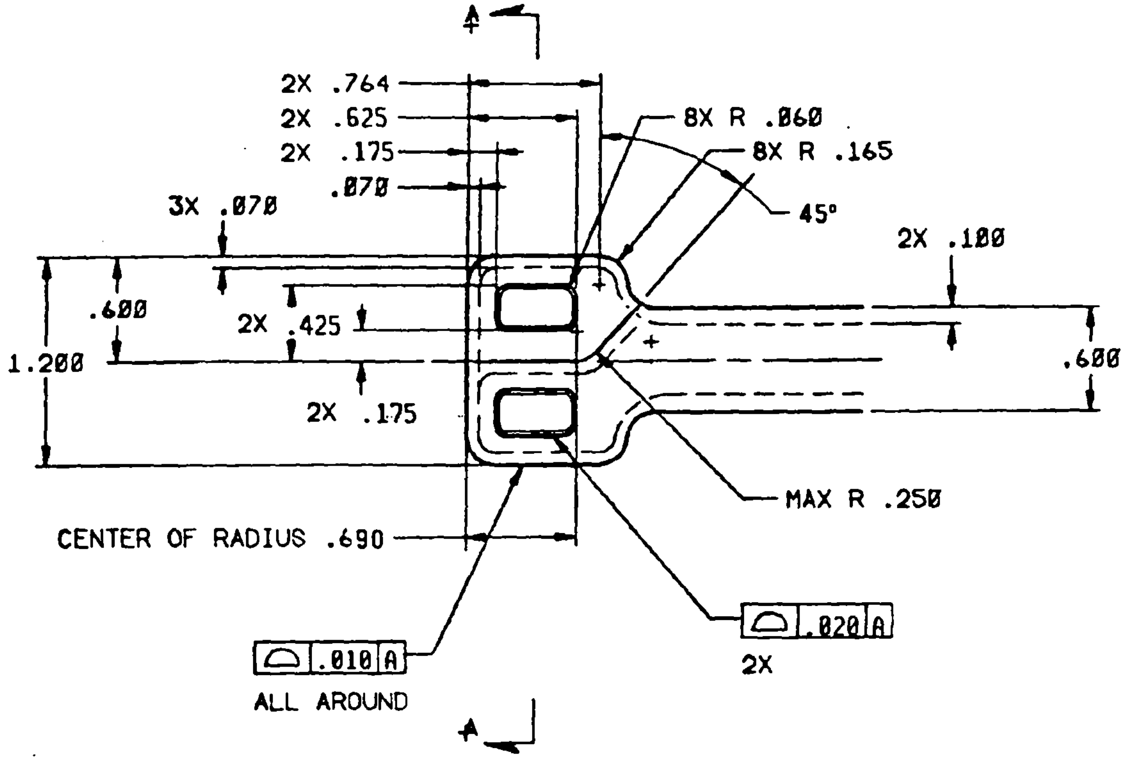
e. Start 2 remaining screws and tighten lightly onto Lid.

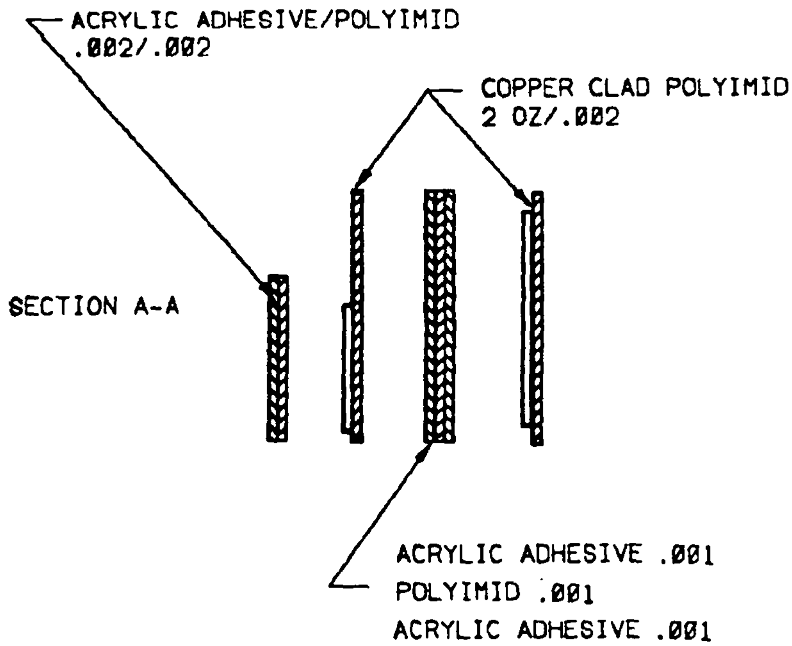
9.4 Continued.

f. Continue tightening screws, approximately 1 turn at a time, alternating diagonally across the pattern.

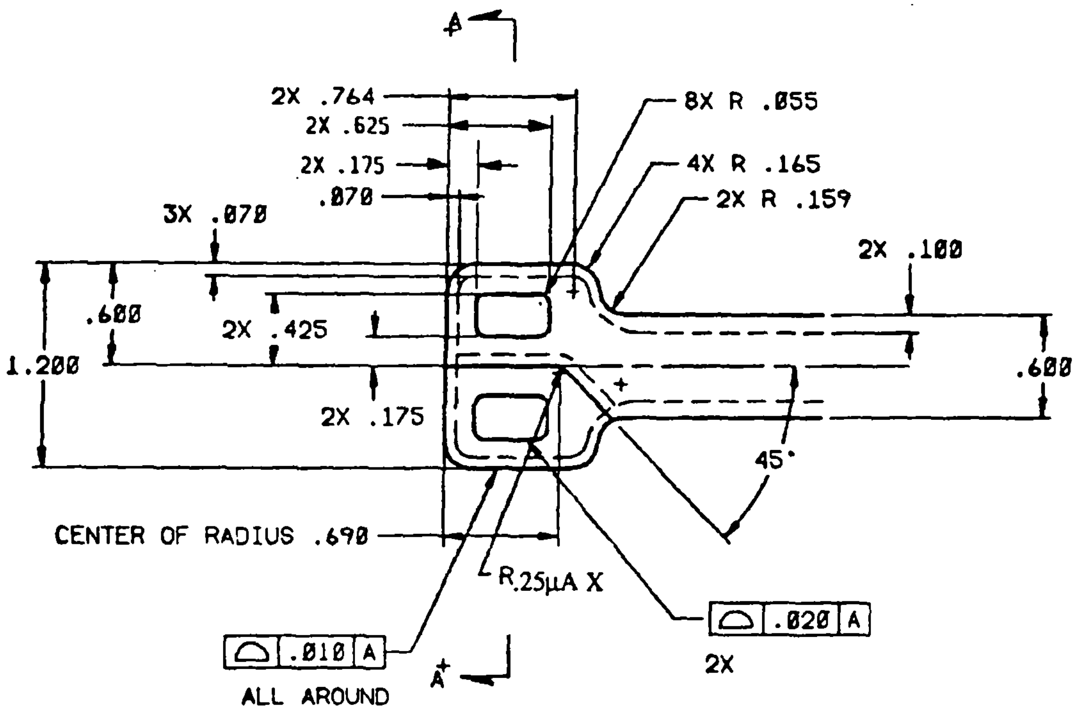
g. Torque each screw to 9.5 ±0.25 in–lb.

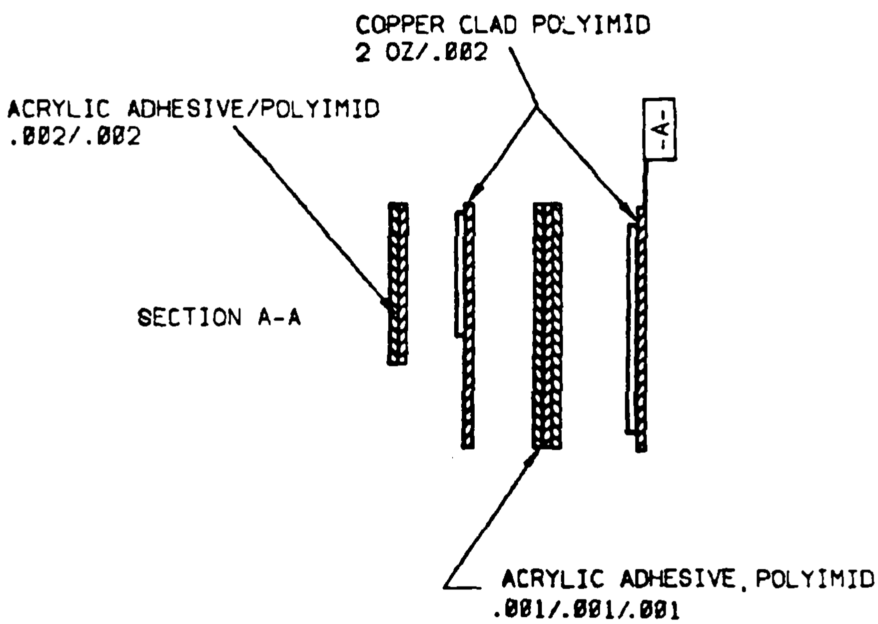
h. Verify the proper assembly by looking through the opening in the Compression Lid. The NG detonator cable should be visible on top of the Contact/Seal. If either of the parts is not visible, the assembly is wrong.





GENERATOR CDU CABLE
FIGURE 1





NG DETONATOR CABLE
FIGURE 2

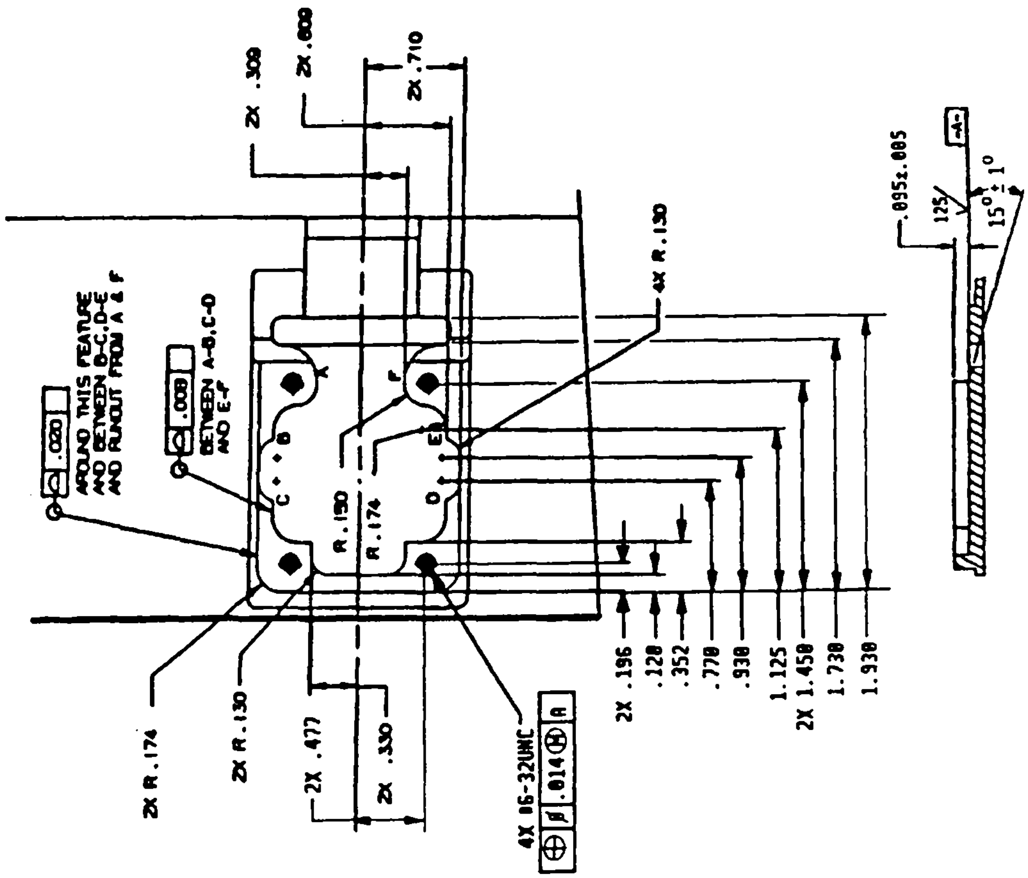
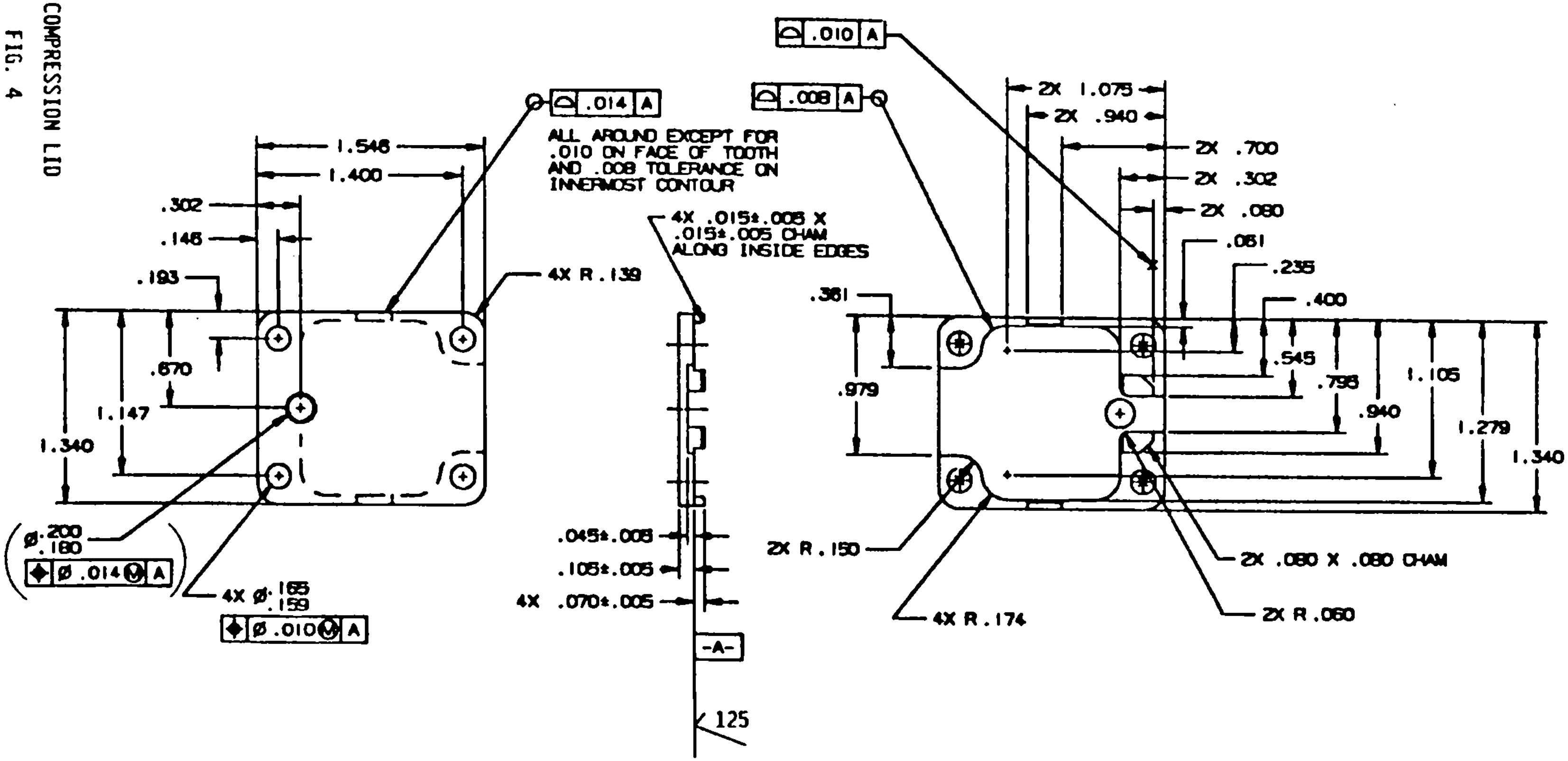


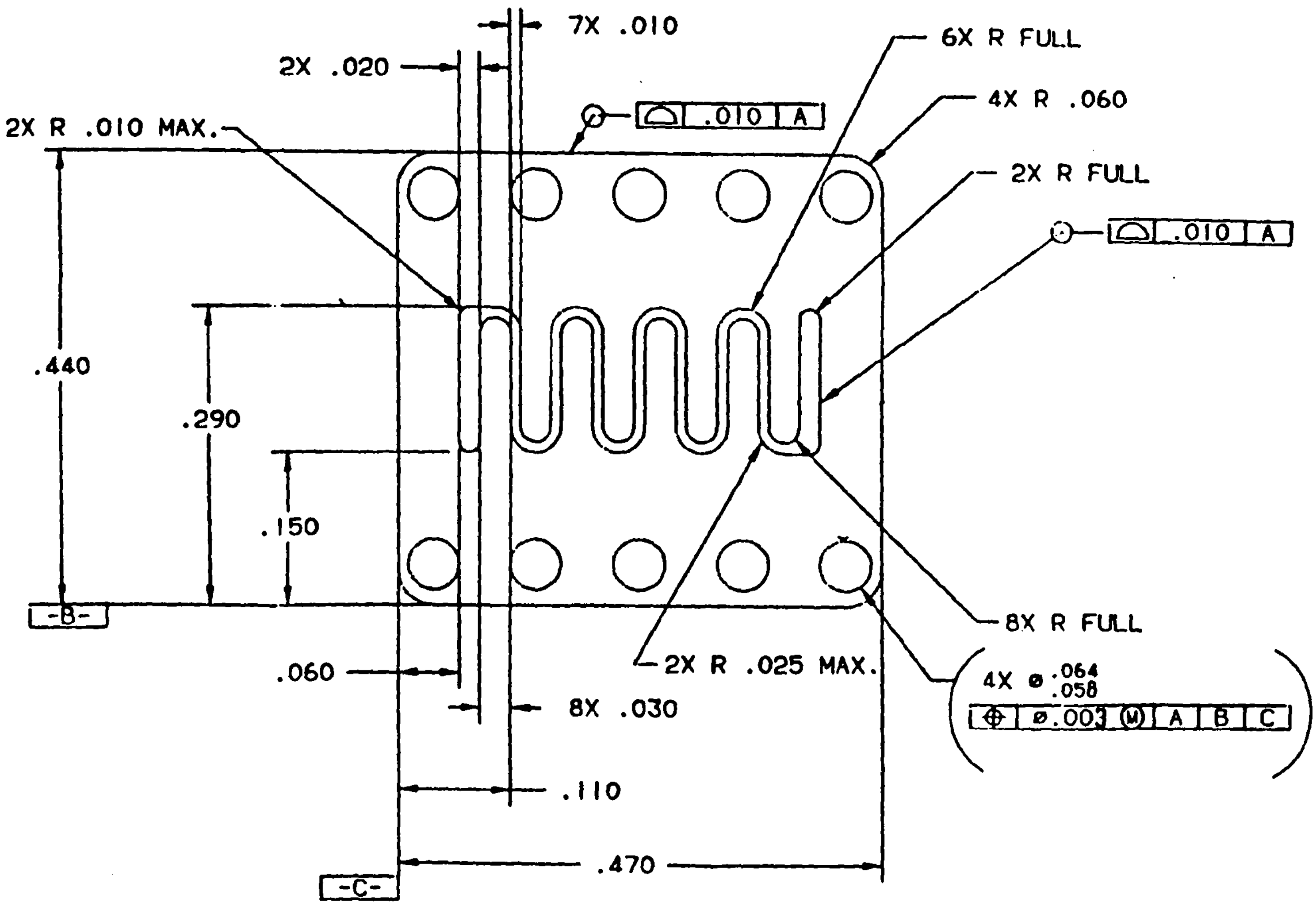
FIGURE 3

NG COMPRESSION LID

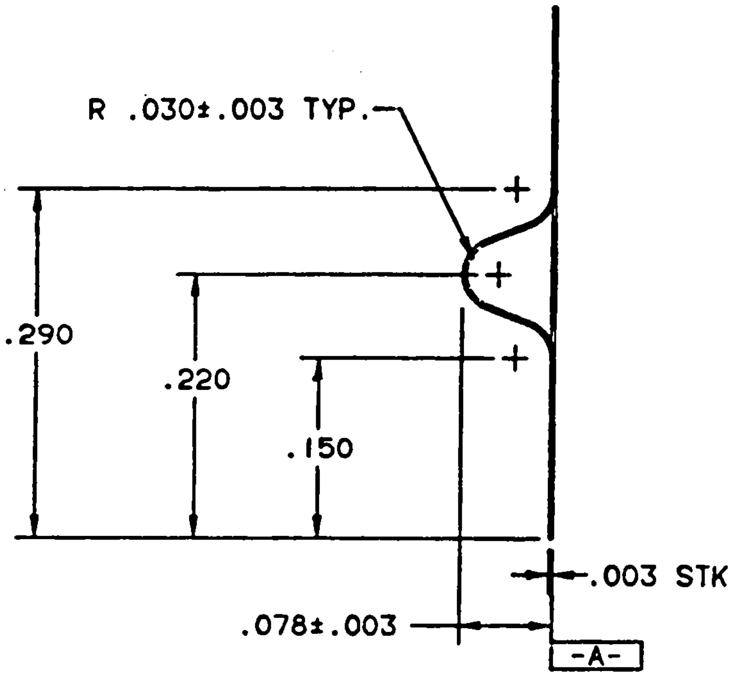
FIG. 4



SPRING CONTACT
FIG. 5A

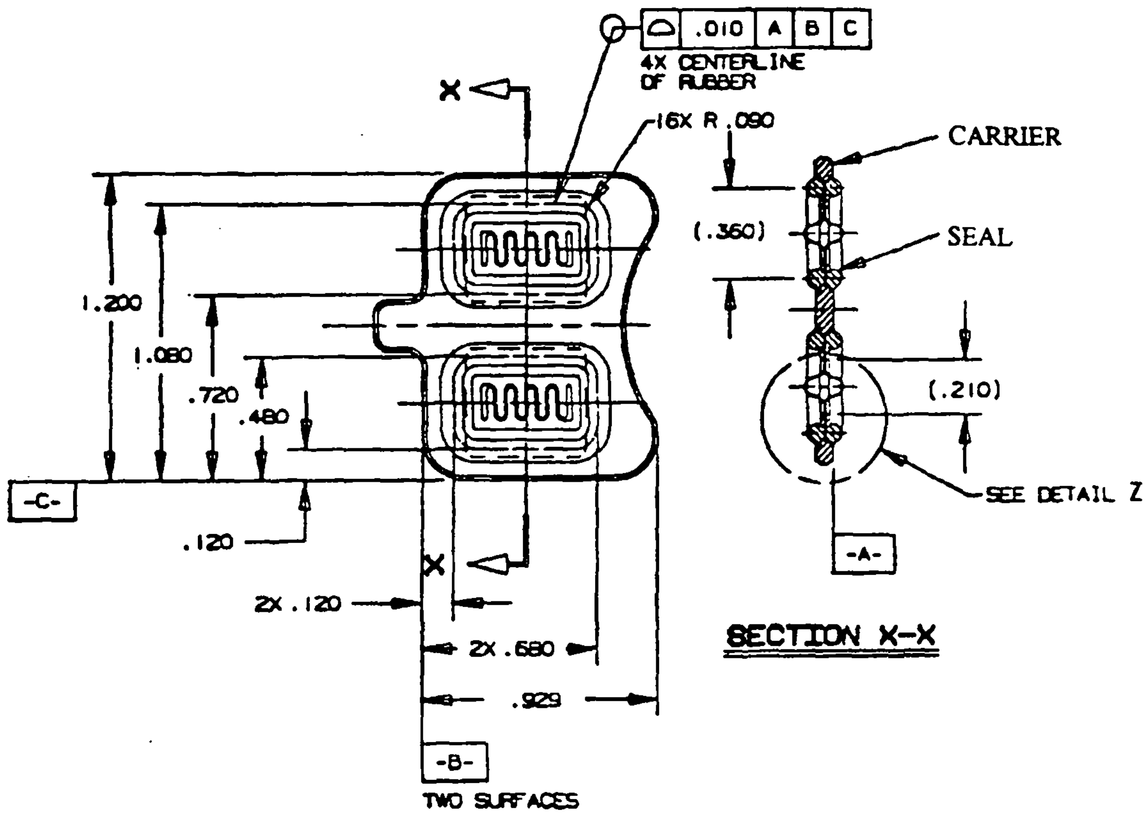


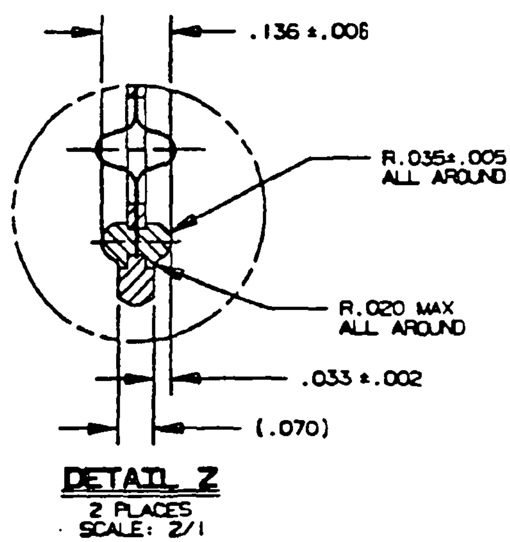
PRIOR TO FORMING



AFTER FORMING

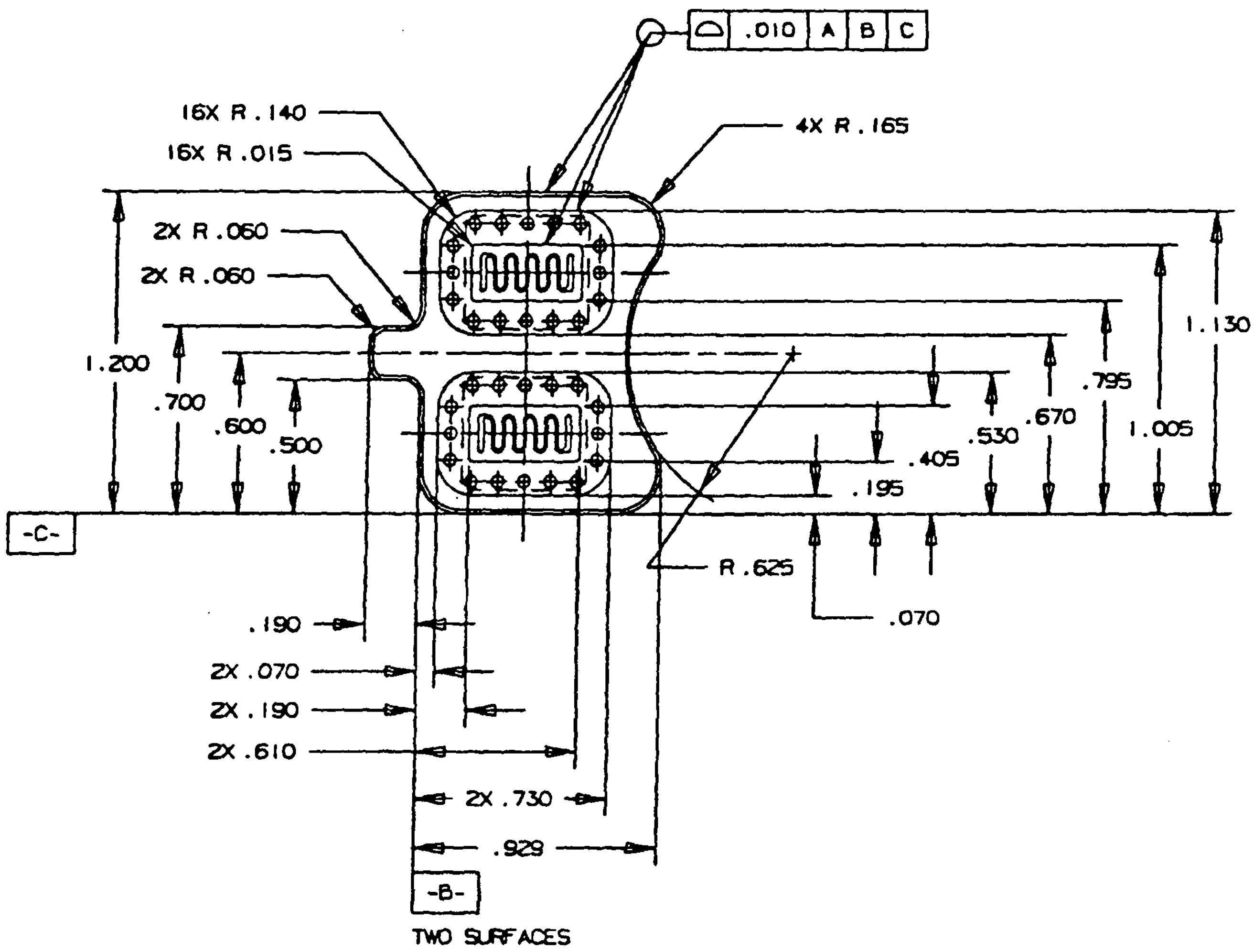
FIG. 5B





NG CONTACT/SEAL ASSEMBLY
FIG. 6A

DETAIL Y



NG CONTACT/SEAL SUBASSEMBLY
FIG. 6B

5/7/92

	SUPVR	ENGINEER
2551	E.T. Cull	Dale J. Hudson
8154	R.S. ...	...
8155	N.A. Schneider	Jeffrey ...
L125		

ULIBARRI 2833 ... 5-7-92

SERIES CONNECTION, W89 (U)

PAGE	1	2	3	4	5	6	7	8	9	10	11	12	13
ISSUE	B	B	B	B	B	B	B	B	B	B	B	B	B

1. GENERAL

1.1 Scope: This document defines the high voltage electrical connection between the cables from LLNL to the MC4069 Firing Set.

1.2 Description: The cables from LLNL (Figure 1,2) are located by two mounting pins in a pocket of the Firing Set Deck (Figure 4). Contact areas on each cable are oriented so they match up with the contact area of the cable when positioned onto the mounting pins. Spring contacts (Fig. 3) molded into the Contact/Seal Assembly (Fig. 6) make electrical contact between the two mating cables. A silicone rubber seal molded mating into the Contact/Seal Assembly (Figure 6) provides the dielectric barrier between the two contacts as well as between contacts and the Deck and mounting pins. The assembly is compressed together between the Deck and the Feed Thru (Figure 5).

1.3 Control. Initial release and subsequent changes to this document require approval of the supervisors and engineers of the following organizations: 2551, 8155, L125, and 2833.

2. DOCUMENTS AND EQUIPMENT

The following documents form a part of this specification to the extent stated herein.

SB210447	W89 Component Environments
455741	Feed Thru
455676	Deck, Complete Assembly
256081	Cable, S
256082	Cable, L

2. Continued.

CD456024	Control Drawing, W89 Series Connection HVLI
393049	Contact Spring, HVLI Assembly
9902112	Gold Plate, Electrodeposited
9902105	Nickel Plate, Electrodeposited
SS391425	Rubber, Silicone Gasket Material
7710000	Titanium Alloy, 6AL–4V, Bars, Annealed
2323952	Cover Coat
2332722	Copper Clad
QQ–N–290	Nickel Plating, Electrodeposited
MIL–G–45204	Gold Plating, Electrodeposited
392922	Contact and Seal Assembly, Series
2221007	Molding Compound, PEEK D150GL30

3. **CABLE, S**

3.1 Materials: The following is a list of materials to be used in fabrication of the flex circuits.

2181044	Adhesive .002
2323952	Polyimid .002/Adhesive .002
2332722	Polyimid .002/Copper Clad 2 oz.

3.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches thick per QQ–N–290, followed by electrodeposited gold .0001 minimum thick per MIL–G–45204, Type II, Grade C.

3.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

3.3 Dimensions: Figure 1 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 1. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

4. CABLE, L

4.1 Materials: The following is a list of materials to be used for fabrication of flex circuits.

2181044	Adhesive .002
2323952	Polyimid .002/Adhesive .002
2332722	Polyimid .002/Copper Clad 2 oz.

4.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0005 inches thick per QQ–N–290, followed by electrodeposited gold .0001 inches minimum thick per MIL–G–45204, Type II, Grade C.

4.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

4.3 Dimensions: Figure 2 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 2. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

5. SPRING CONTACT

5.1 Material: Beryllium Copper per 7513015. Heat treat for 2 to 2.5 hours at 650 to 675 degrees F.

5.2 Plating: The contact areas of the cable shall be plated with electrodeposited nickel .0001 to .0003 inches thick per 9902105, followed by electrodeposited gold .00005 to .00015 inches thick per 9902112 Type II, Class 3.

5.2.1 Plating Damage. Nicks, scratches and gouges are acceptable on the plated surface as long as they are less than .030 inches wide and do not expose the nickel plated area below the gold.

5.3 Dimensions: Figure 3 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 3. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

6. DECK

6.1 Material: Titanium per 7710000.

6.2 Dimensions: Figure 4 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 4. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

7. FEED THRU

7.1 Material: Corrosion resistant steel per 7341000.

7.2 Finish: Passivate per 9904301.

7.3 Dimensions: Figure 5 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 5. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

8. CONTACT AND SEAL ASSEMBLY, SERIES

8.1 Material: Fabricate and inspect Silicon rubber seal per SS391425.

8.2 Fabricate carrier portion of assembly from PEEK per 2221007.

8.3 Dimensions: Figure 6 shows the dimensions that are critical to the function of this design, dimensions in parentheses are for reference only. The dimensions on the part defining drawing shall be consistent with those in Figure 6. Attached to each of the critical dimensions on the graphic drawing shall be a flagnote referencing this document.

9. ASSEMBLY

9.1 Handling: Finger cots or lint free gloves shall be worn during the assembly operation.

9.2 Parts shall be free of foreign material and other contaminants. All cleaning shall be done per SNL approved procedures.

9.3 Assembly Procedure:

a. Place Cable S onto mounting pins in Deck.

b. Place Contact/Seal onto Cable S and locate on mounting pins in Deck.

c. Bring Cable L into position and locate on mounting pins in Deck, on top of the Contact/Seal.

d. Place the Feed Thru on top and align the screw holes with those in the Deck and start the screws a few turns into their holes.

e. Continue tightening screws, approximately 1 turn at a time, alternating diagonally across the pattern.

9.3 Continued.

f. Torque screws to 8.0 ±0.25 in.–lbs.

g. Verify the proper assembly by looking through the opening in the Feedthru. Cable L should be visible on top of the Contact/Seal which should be visible on top of Cable S. If any of the parts are not visible, the assembly is wrong.

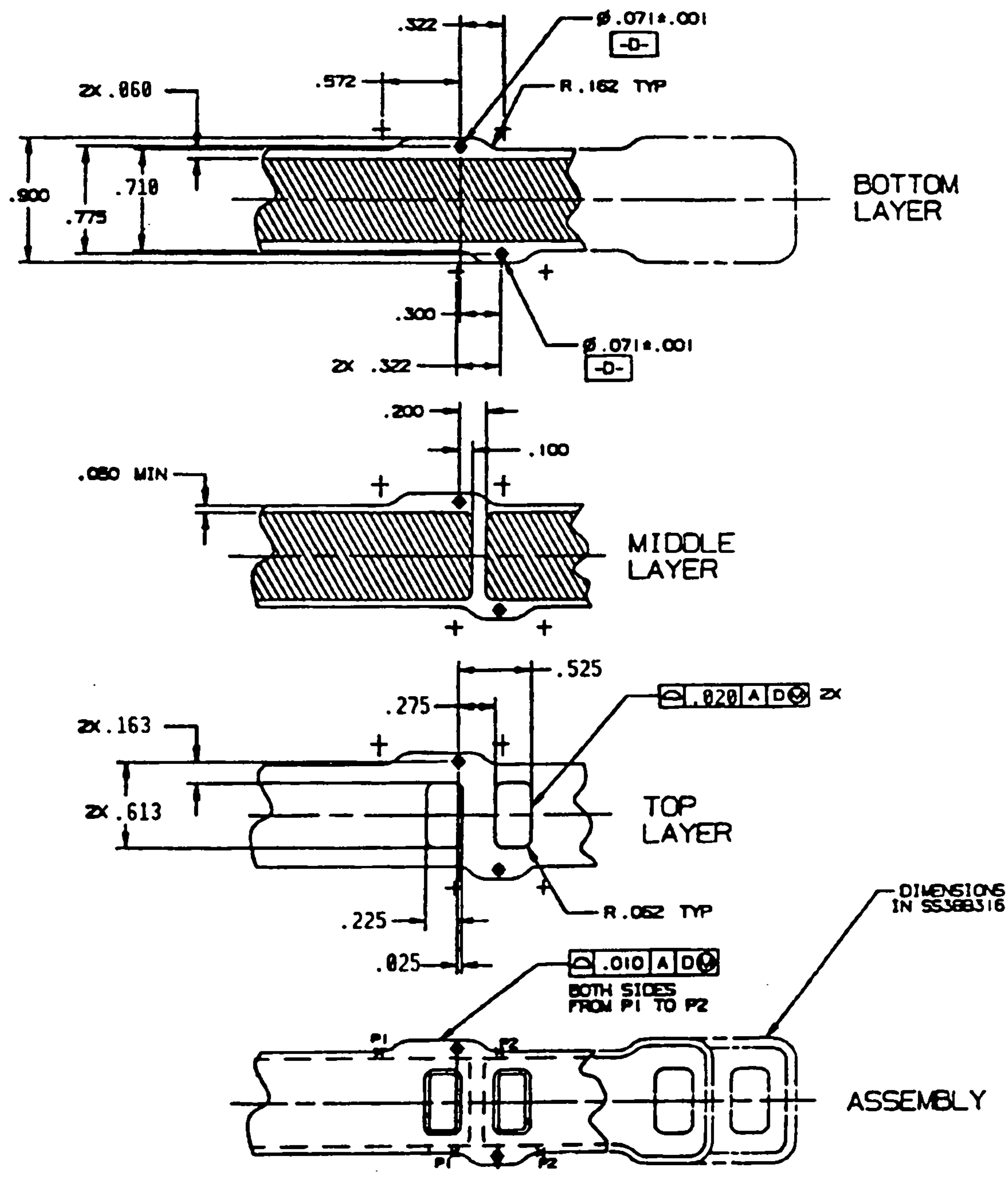
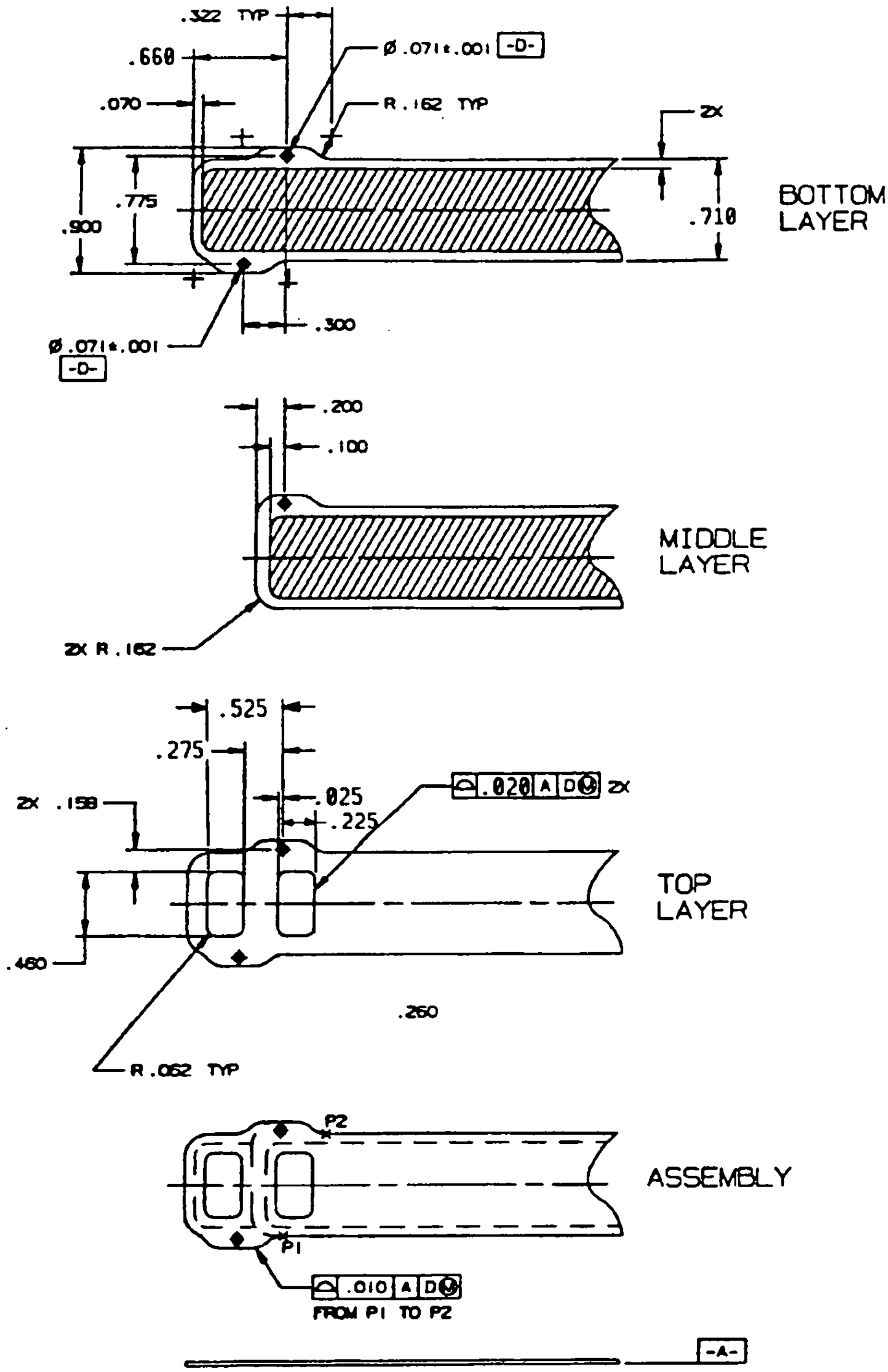
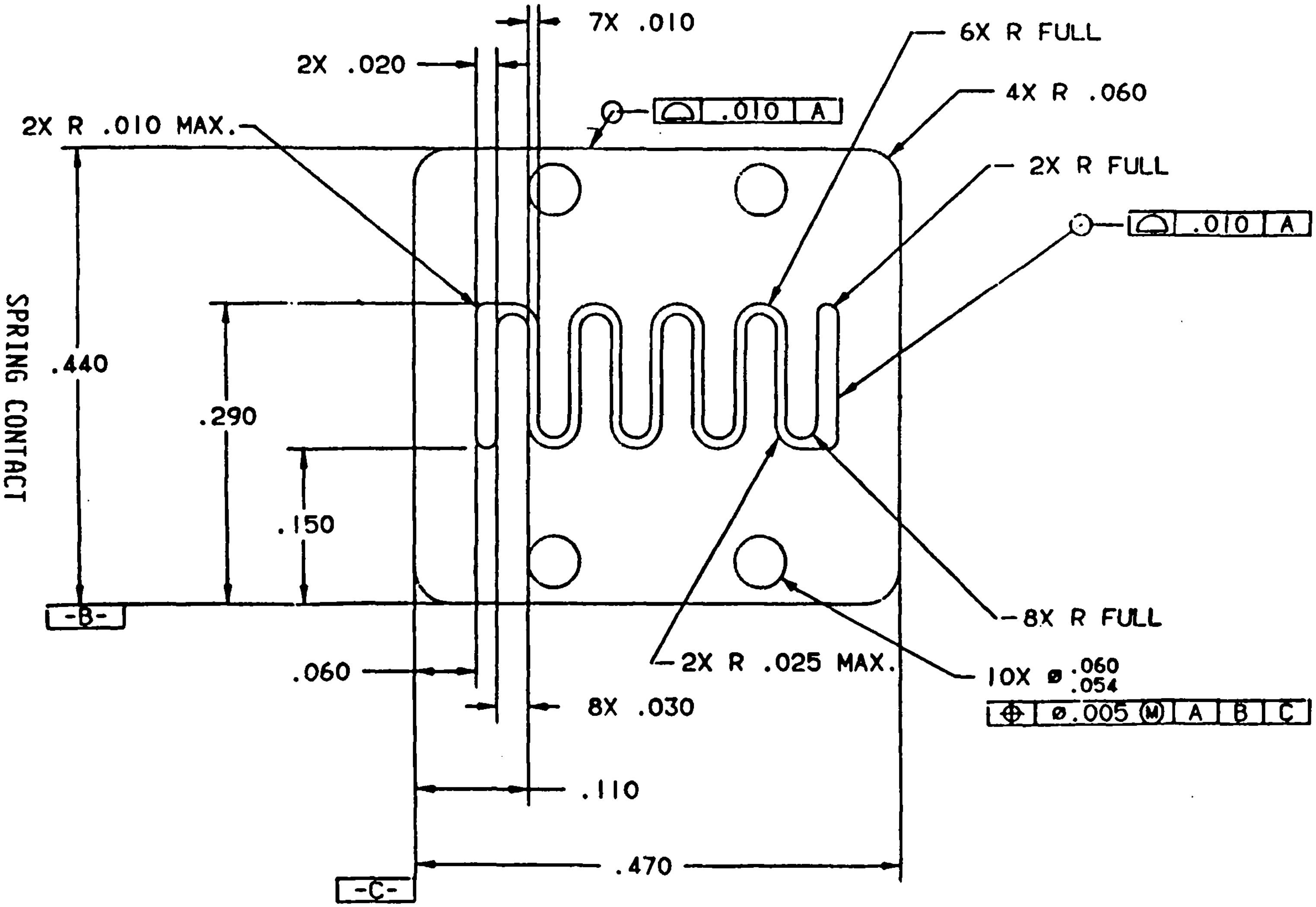

.322
Ø .071±.001
-D-
.572
2X .060
R .162 TYP
.900
.710
.775
BOTTOM
LAYER
.300
Ø .071±.001
-D-
2X .322
.200
.100
.060 MIN
MIDDLE
LAYER
.525
.275
.020 A D 2X
2X .163
2X .613
TOP
LAYER
R .062 TYP
.225
.025
DIMENSIONS
IN SS388316
.010 A D
BOTH SIDES
FROM P1 TO P2
P1
P2
ASSEMBLY

FIGURE 1

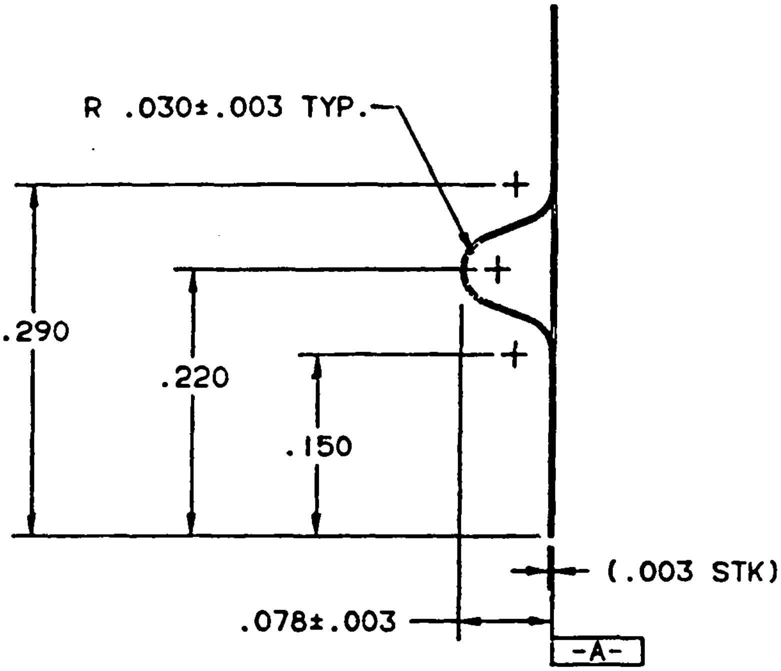


CABLE L
FIGURE 2

SPRING CONTACT
FIGURE 3A



PRIOR TO FORMING

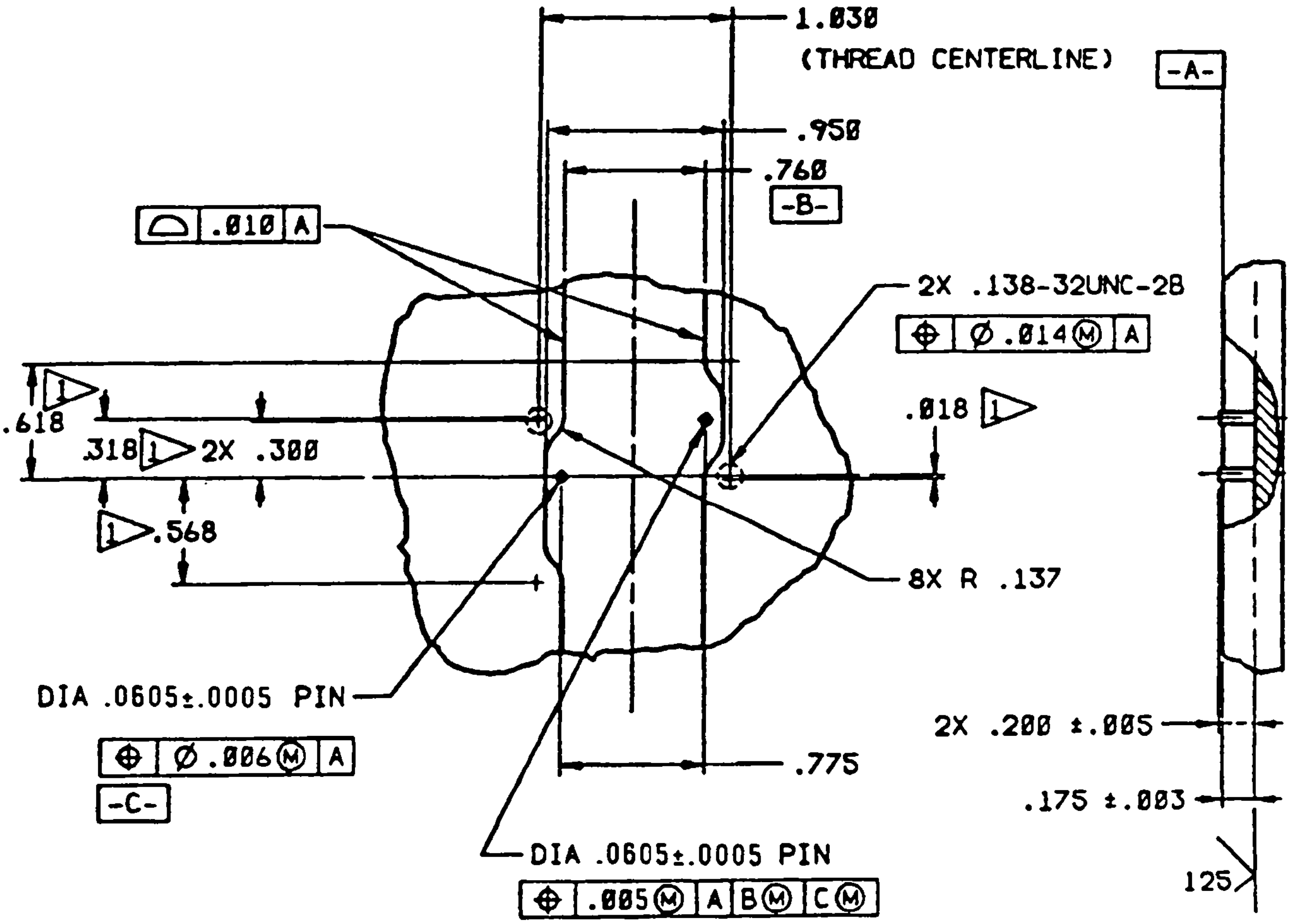


AFTER FORMING

SPRING CONTACT
FIG. 3B

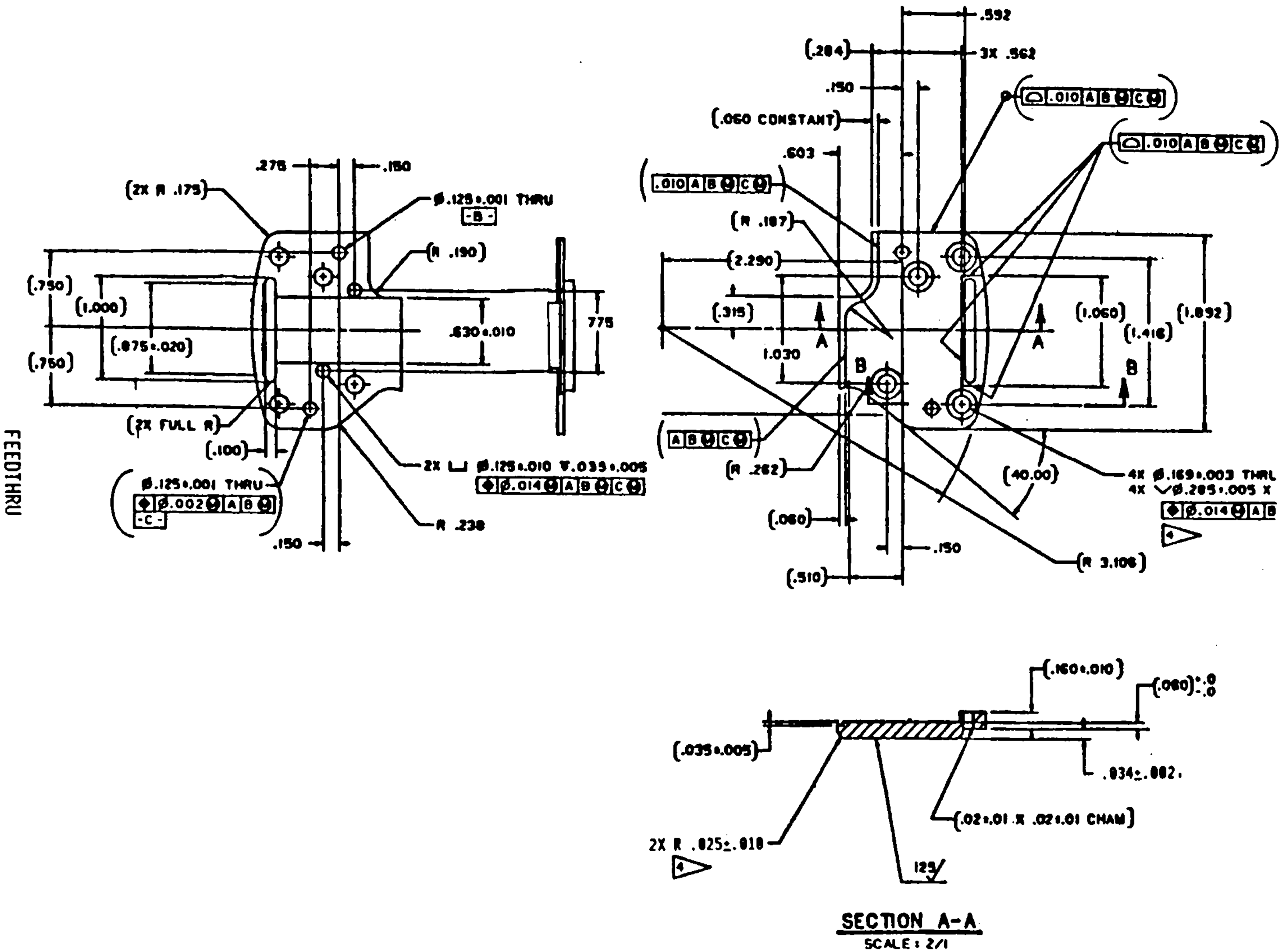
NOTES:

1 DIMENSION TO CENTER OF RADIUS FOR POCKET.

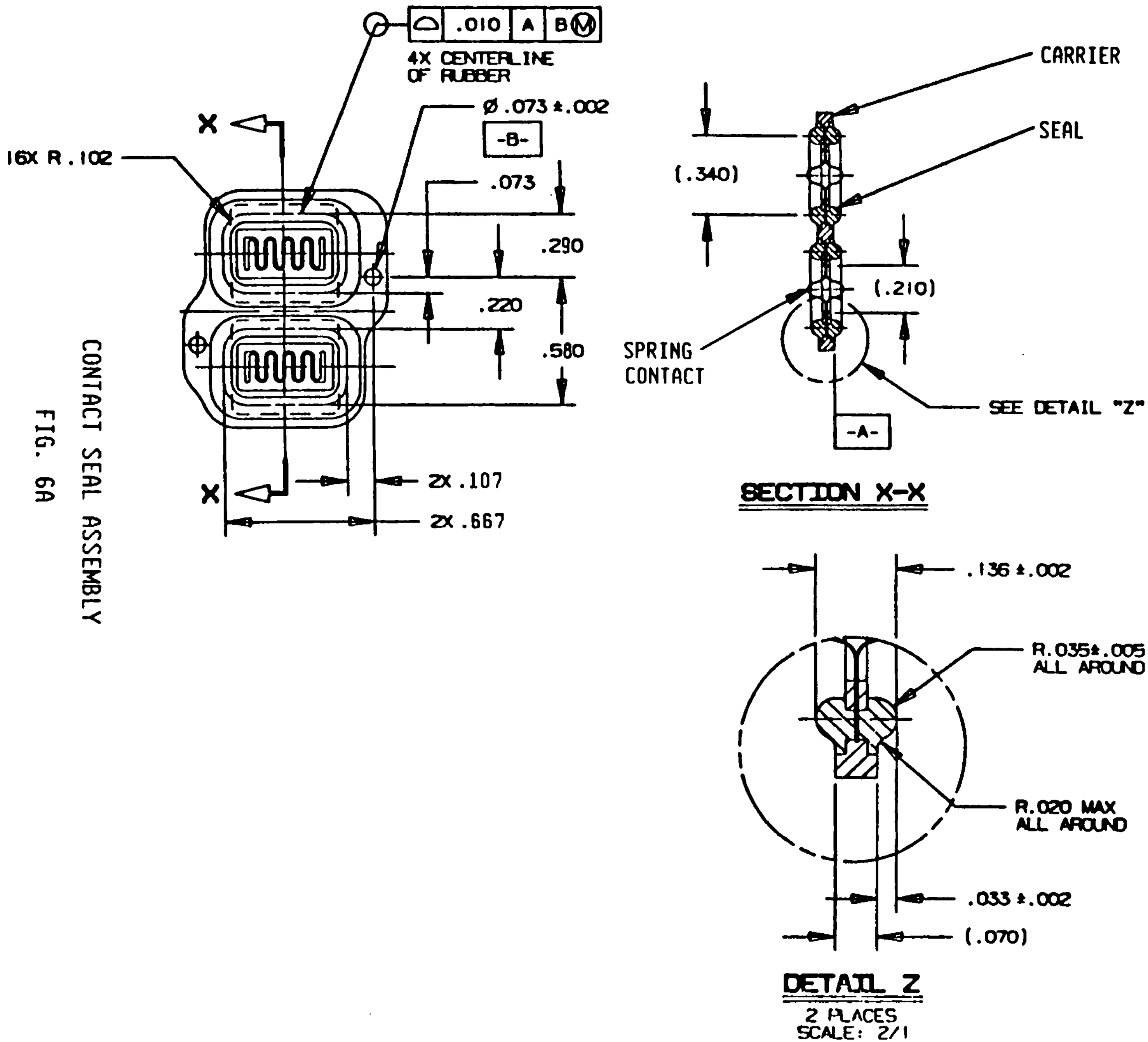


FIRE SET DECK

FIG. 4

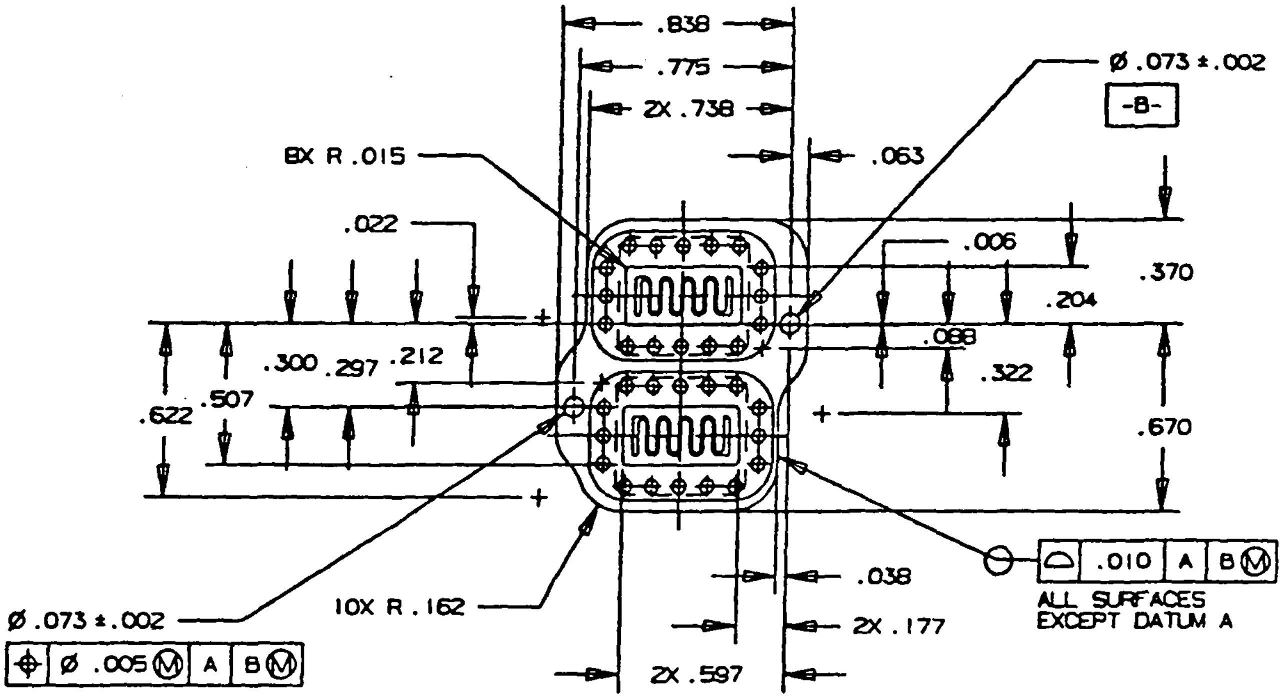


FEEDTHRU
FIGURE 5



CONTACT SEAL ASSEMBLY

FIG. 6A



CONTACT/SEAL SUBASSEMBLY

FIG. 6B

APPENDIX B

Dimensional Studies

20-Nov-92 MAIN CDU COMPRESSION

	NOMINAL DIMENSIONS		TOLERANCES (+-)
0.2270	Pocket Depth	0.0050	Pocket
0.0870	Lid Step	0.0020	Lid
0.1360	Gasket Hieght (free)	0.0060	Gasket
0.1560	Spring Height (free)	0.0060	Spring
0.0236	Main CDU Cable (total)	0.0024	Main CDU Cable
0.0098	Det Cable thk (half)	0.0010	Det Cable

MAIN CABLE THICKNESS		DET CABLE THICKNESS	
0.0058	2/2 copper/polyimid	0.0058	2/2 copper/polyimid
0.0040	Adhesive 2X	0.0040	2/2 covercoat
0.0040	2/2 Covercoat		
0.0058	2/2 copper/polyimid	0.0098	Det Cable thk (half)
0.0040	2/2 Covercoat		
0.0236	Main CDU Cable (total)		

SPRING COMPRESSION

0.2270	Pocket Depth	0.0050	Pocket
-0.0870	Lid Step	0.0020	Lid
-0.0236	Main CDU Cable (total)	0.0024	Main CDU Cable
-0.0098	Det Cable thk (half)	0.0010	Det Cable
0.0040	2/2 Covercoat	0.0004	2/2 Covercoat
0.0040	2/2 Covercoat	0.0004	2/2 Covercoat
0.1146	Compressed height	0.0111	-/+
0.1560	Spring Height (free)	0.0060	Spring
0.0414	Compression	0.01714	-/+
	0.059 max		
	0.024 min		

GASKET COMPRESSION

0.2270	Pocket Depth	0.0050	Pocket
-0.0870	Lid Step	0.0020	Lid
-0.0236	Main CDU Cable (total)	0.0024	2/2 Covercoat
-0.0098	Det Cable thk (half)	0.0010	2/2 Covercoat
0.1066	Compressed height	0.0103	-/+
0.1360	Gasket Hieght (free)	0.0060	Gasket
0.0294	Compression	0.0163	-/+
	0.046 max		
	0.013 min		

20-Nov-92 NG CDU COMPRESSION

NOMINAL DIMENSIONS		TOLERANCES (+-)	
0.0950	Pocket Depth	0.0050	Pocket
0.0450	Lid Step	0.0050	Lid
0.1360	Gasket Hieght (free)	0.0060	Gasket
0.1560	Spring Height (free)	0.0060	Spring
0.0186	NG CDU Cable (total)	0.0019	NG CDU Cable
0.0098	NG Cable thk (half)	0.0010	NG Cable

MAIN CABLE THICKNESS		DET CABLE THICKNESS	
0.0058	2/2 copper/polyimid	0.0058	2/2 copper/polyimid
0.0030	1/1/1 Polyimid/Adhesive	0.0040	2/2 covercoat
0.0058	2/2 copper/polyimid	----------	
0.0040	2/2 Covercoat	0.0098	NG Cable thk (half)

0.0186	NG CDU Cable (total)		

SPRING COMPRESSION

0.0950	Pocket Depth	0.0050	Pocket
0.0450	Lid Step	0.0050	Lid
-0.0186	NG CDU Cable (total)	0.0019	NG CDU Cable
-0.0098	NG Cable thk (half)	0.0010	NG Cable
0.0040	2/2 Covercoat	0.0004	2/2 Covercoat
0.0040	2/2 Covercoat	0.0004	2/2 Covercoat
----------		----------	
0.1196	Compressed height	0.0136	-/+
0.1560	Spring Height (free)	0.0060	Spring
----------		----------	
0.0364	Compression	0.01964	-/+
	0.056 max		
	0.017 min		

GASKET COMPRESSION

0.0950	Pocket Depth	0.0050	Pocket
0.0450	Lid Step	0.0050	Lid
-0.0186	NG CDU Cable (total)	0.0019	NG CDU Cable
-0.0098	NG Cable thk (half)	0.0010	NG Cable
----------		----------	
0.1116	Compressed height	0.0128	-/+
0.1360	Gasket Hieght (free)	0.0060	Gasket
----------		----------	
0.0244	Compression	0.0188	-/+
	0.043 max		
	0.006 min		

20-Nov-92 SERIES COMPRESSION

NOMINAL DIMENSIONS		TOLERANCES (+-)	
0.1750	Pocket Depth	0.0030	Pocket
0.0340	Lid Step	0.0020	Lid
0.0660	Gasket Hieght (free)	0.0060	Gasket
0.1560	Spring Height (free)	0.0060	Spring
0.0313	Nominal Stackup (total)	0.0070	Total both cables
0.0700	Carrier thk	0.0020	Carrier

CABLE S THICKNESS

0.0058	2/2 copper/polyimid
0.0020	Adhesive
0.0058	2/2 copper/polyimid
0.0040	2/2 Covercoat
0.0176	Cable S (total)

CABLE L THICKNESS

0.0058	2/2 copper/polyimid
0.0040	2/2 covercoat
0.0098	Cable L thk (half)

0.0274 thk #1 0.0352 thk #2

0.0313	Nominal Stackup (total)
0.0039	Step tolerance
0.0031	thk tolerance

SPRING COMPRESSION

0.1750	Pocket Depth	0.0030	Pocket
-0.0340	Lid Step	0.0020	Lid
-0.0313	Nominal Stackup (total)	0.0070	Total both cables
0.0058	2/2 copper/polyimid	0.0006	2/2 copper/polyimid
0.0058	2/2 copper/polyimid	0.0006	2/2 copper/polyimid
0.1213	Compressed height	0.0132	-/+
0.1560	Spring Height (free)	0.0060	Spring
0.0347	Compression	0.01919	-/+

0.054 max
0.016 min

GASKET COMPRESSION

0.1750	Pocket Depth	0.0030	Pocket
-0.0340	Lid Step	0.0020	Lid
-0.0313	Nominal Stackup (total)	0.0070	Total both cables
-0.0700	Carrier thk	0.0020	Carrier
0.0397	Compressed height (rubber)	0.0140	-/+
0.0660	Gasket Hieght (free)	0.0060	Gasket
0.0263	Compression	0.0200	-/+

0.046 max
0.006 min

20-Nov-92 NG CDU TOLERANCE STUDY

<<<<DIMENSIONS>>>>>

Width	Length	
0.200	0.398	Window in Fireset Cable
0.200	0.398	Window in Det Cable
0.300	0.496	Rib Center-Line
0.400	0.600	Copper Fireset Cable (one side only)
0.398	0.594	Copper Det Cable
0.110	0.310	Contact (baseline)

<<<<TOLERANCES>>>>

0.008	Mounting block pocket contour
0.010	Fireset cable contour
0.010	Fireset cable top cover coat edge
0.010	Fireset cable window contour
0.007	Fireset Contact location tolerance
0.010	Det cable contour
0.010	Det cable window contour
0.012	Gasket contour
0.012	Gasket Rib center-line to Gasket edge
0.010	Conductor pattern tolerance

<<<<CLEARANCE @ LMC>>>>> assume line to line at MMC

0.008		Mounting block pocket contour
0.010		Fireset cable contour

0.018	0.036	max total clearance Fireset cable in pocket

0.008		Mounting block pocket contour
0.010		Det cable contour

0.018	0.036	max total clearance Det cable in pocket

0.008		Mounting block pocket contour
0.012		Gasket contour

0.02	0.04	max total clearance gasket to pocket

<<<<GASKET RIB CENTER-LINE TO CABLE WINDOW EDGE>>>>

***FIRE SET CABLE

width	length	
0.300	0.496	Rib Center-Line
0.200	0.398	Window in Fireset Cable
----	----	
0.100	0.098	difference
-0.010	-0.010	Fireset cable window contour
-0.012	-0.012	Gasket Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Fireset cable in pocket
-0.040	-0.040	max total clearance gasket to pocket
----	----	
0.002	0.000	

****DET CABLE

width	length	
0.300	0.496	Rib Center-Line
0.200	0.398	Window in Det Cable
----	----	
0.100	0.098	difference
-0.010	-0.010	Fireset cable window contour
-0.012	-0.012	Gasket Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Fireset cable in pocket
-0.040	-0.040	max total clearance gasket to pocket
----	----	
0.002	0.000	

<<<<RIB CENTERLINE TO COPPER EDGE>>>>

****FIRESET CABLE

width	length	
0.400	0.600	Copper Fireset Cable (one side only)
-0.300	-0.496	Rib Center-Line
----	----	
0.100	0.104	difference
-0.010	-0.010	Conductor pattern tolerance
-0.012	-0.012	Gasket Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Fireset cable in pocket
-0.040	-0.040	max total clearance gasket to pocket
----	----	
0.002	0.006	

****DET CABLE

width	length	
0.398	0.594	Copper Det Cable
0.300	0.496	Rib Center-Line
----	----	
0.098	0.098	difference
-0.010	-0.010	Conductor pattern tolerance
-0.012	-0.012	Gasket Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Det cable in pocket
-0.040	-0.040	max total clearance gasket to pocket
----	----	
0.000	0.000	

20-Nov-92 MAIN CDU TOLERANCE STUDY

<<<<DIMENSIONS>>>>>

Width	Length	
0.250	0.450	Window in Fireset Cable
0.250	0.450	Window in Det Cable
0.360	0.560	Rib Center-Line
0.460	0.760	Copper Fireset Cable (one side only)
0.480	0.780	Copper Det Cable

<<<<TOLERANCES>>>>

0.008	Mounting block pocket contour
0.010	Fireset cable contour
0.010	Fireset cable top cover coat edge
0.020	Fireset cable window contour
0.007	Fireset Contact location tolerance
0.010	Det cable contour
0.020	Det cable window contour
0.010	Carrier contour
0.010	Rib center-line to Gasket edge
0.010	Conductor pattern tolerance

<<<<CLEARANCE @ LMC>>>>> assume line to line at MMC

0.008		Mounting block pocket contour
0.010		Fireset cable contour
—		
0.018	0.036	max total clearance Fireset cable in pocket

0.008		Mounting block pocket contour
0.010		Det cable contour
—		
0.018	0.036	max total clearance Det cable in pocket

0.008		Mounting block pocket contour
0.010		Carrier contour
—		
0.018	0.036	max total clearance gasket to pocket

<<<<GASKET RIB CENTER-LINE TO CABLE WINDOW EDGE>>>>

***FIRE SET CABLE

width	length	
0.360	0.560	Rib Center-Line
0.250	0.450	Window in Fireset Cable
—	—	
0.110	0.110	difference
-0.020	-0.020	Fireset cable window contour
-0.010	-0.010	Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Fireset cable in pocket
-0.036	-0.036	max total clearance gasket to pocket
—	—	
0.008	0.008	

****DET CABLE

width	length	
0.360	0.560	Rib Center-Line
0.250	0.450	Window in Det Cable
—	—	
0.110	0.110	difference
-0.020	-0.020	Fireset cable window contour
-0.010	-0.010	Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Fireset cable in pocket
-0.036	-0.036	max total clearance gasket to pocket
—	—	
0.008	0.008	

<<<<RIB CENTERLINE TO COPPER EDGE>>>>

****FIRESET CABLE

width	length	
0.460	0.760	Copper Fireset Cable (one side only)
-0.360	-0.560	Rib Center-Line
—	—	
0.100	0.200	difference
-0.010	-0.010	Conductor pattern tolerance
-0.010	-0.010	Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Fireset cable in pocket
-0.036	-0.036	max total clearance gasket to pocket
—	—	
0.008	0.108	

****DET CABLE

width	length	
0.480	0.780	Copper Det Cable
0.360	0.560	Rib Center-Line
—	—	
0.120	0.220	difference
-0.010	-0.010	Conductor pattern tolerance
-0.010	-0.010	Rib center-line to Gasket edge
-0.036	-0.036	max total clearance Det cable in pocket
-0.036	-0.036	max total clearance gasket to pocket
—	—	
0.028	0.128	

20-Nov-92 SERIES CONNECTION TOLERANCE STUDY

<<<<DIMENSIONS>>>>>

Width	Length		
0.2500		0.4500	Window in Cable 1
0.2500		0.4500	Window in Cable 2
0.3600		0.5600	Rib Center-Line
0.4000		0.5900	Copper Cable 1 (one side only)
0.4000		0.5900	Copper Cable 2
0.2000		0.4000	Contact (baseline)
0.0605	Dia		Dowel Pin
0.0710	Dia		Cable Holes
0.0730	Dia		Gasket Hole

<<<<TOLERANCES>>>>

0.0005	Dowel Pin tolerance (plus/minus)
0.0010	Cable 1 hole tolerance (plus/minus)
0.0200	Cable 1 window contour
0.0070	Contact location tolerance
0.0200	Cable 2 window contour
0.0020	Gasket Hole tolerance
0.0100	Gasket Rib center-line to Gasket edge
0.0100	Conductor pattern tolerance

<<<<CLEARANCE @ LMC>>>>>

0.0720	Max Cable 1 Hole
0.0600	Min Dowel Pin

0.0120	max total clearance Cable 1 Hole to Dowel Pin

0.0750	Max Gasket hole
0.0600	Min dowel pin

0.0150	max total clearance gasket to Dowel Pin

0.0720	Max Cable 2 Hole
0.0600	Min Dowel Pin

0.0120	max total clearance Cable 2 Hole to Dowel Pin

<<<<GASKET RIB CENTER-LINE TO CABLE WINDOW EDGE>>>>

***CABLE 1

width	length	
0.3600	0.5600	Gasket
0.2500	0.4500	Cable
-----	-----	
0.1100	0.1100	difference
-0.0200	-0.0200	Cable 1 window contour
-0.0100	-0.0100	Gasket Rib center-line to Gasket edge
-0.0120	-0.0120	max total clearance Cable 1 Hole to Dowel Pin
-0.0150	-0.0150	max total clearance gasket to Dowel Pin
-----	-----	
0.0530	0.0530	

****CABLE 2

width	length	
0.3600	0.5600	Rib Center-Line
0.2500	0.4500	Window in Cable 2
-----	-----	
0.1100	0.1100	difference
-0.0200	-0.0200	Cable 1 window contour
-0.0100	-0.0100	Gasket Rib center-line to Gasket edge
-0.0120	-0.0120	max total clearance Cable 2 Hole to Dowel Pin
-0.0150	-0.0150	max total clearance gasket to Dowel Pin
-----	-----	
0.0530	0.0530	

<<<<RIB CENTERLINE TO COPPER EDGE>>>>

****CABLE 1

width	length	
0.4000	0.5900	Copper Cable 1 (one side only)
-0.3600	-0.5600	Rib Center-Line
-----	-----	
0.0400	0.0300	difference
-0.0100	-0.0100	Conductor pattern tolerance
-0.0100	-0.0100	Gasket Rib center-line to Gasket edge
-0.0120	-0.0120	max total clearance Cable 1 Hole to Dowel Pin
-0.0150	-0.0150	max total clearance gasket to Dowel Pin
-----	-----	
-0.0070	-0.0170	

****CABLE 2

width	length	
0.4000	0.5900	Copper Cable 2
0.3600	0.5600	Rib Center-Line
-----	-----	
0.0400	0.0300	difference
-0.0100	-0.0100	Conductor pattern tolerance
-0.0100	-0.0100	Gasket Rib center-line to Gasket edge
-0.0120	-0.0120	max total clearance Cable 2 Hole to Dowel Pin
-0.0150	-0.0150	max total clearance gasket to Dowel Pin
-----	-----	
-0.0070	-0.0170	

APPENDIX C

Silicone Rubber

Sandia National Laboratories
Albuquerque, New Mexico 87185

date: March 7, 1989

to: Gordon Grimm (2544)

Peter Green
from: Peter Green (1813)

Subject: Behavior of silicone rubber in humid environments.

You mentioned that for the application where the silicone elastomer will be used it was important to that it absorb as little water as possible. In addition, you also were not sure precisely what temperature and humidity conditions the elastomer would be subjected to. Below is a brief discussion of the behavior of silicone in a variety of humid environments. After determining how much water is tolerable in the elastomer it should be easy to choose the environmental conditions, based on the data presented below, to meet those conditions.

The work of Barrie and coworkers shows that silicone rubber can, under very high humidity conditions, absorb an appreciable amount of its total volume in water at temperatures not much higher than room temperature. Attached are two figures, both of which show how temperature and humidity affects the equilibrium concentration of water in silicone rubber. The first of these figures shows that the equilibrium concentration of water increases appreciably with increased humidity. Note that the units of concentration are volume (cm^3) of water at standard temperature and pressure (STP) per volume (cm^3) of rubber. These are conventional units which I sometimes find confusing. It should be pointed out that in experiments that are performed in order to obtain the solubility of vapors in polymers one obtains solubility in units of grams of vapor (water in this case) per gram of polymer. In order to get the units of C , in this figure, the authors multiplied by the factor:

$$K=\frac{22{,}400.\ \rho(0.97\ g/cm^3,\ \text{polymer})}{M(18\ g/mol\ \text{of water}).}$$

The final units are therefore in $cm^3(STP)/cm^3$. You can use this conversion factor to reconvert to g(water)/g(rubber) if you desire. The solubility coefficient, which is often stated, is obtained by dividing C by the vapor pressure of water, p. For example, the CRC hand book indicates that at $24^{o}C$ the vapor pressure of water is 2.4 cmHg. At a relative humidity of

20%, the vapor pressure is p=0.2x2.4 cmHg. The solubility is therefore C divided by p. Figure 2 shows basically the same thing as figure 1 except that the emphasis is on the effects of temperature. The purpose of this figure is to enable you can extrapolate to different temperatures.

It is clear from this data that the solubility of water into the rubber is influenced appreciably by temperature and humidity. As a basis of comparison, the solubility is not as high as many glassy polymers such as polymethylmethacrylate. Based on this data, however, it is desirable to store the silicone elastomer in an environment where there is a *dessicant* and, if possible, where the temperature is relatively low.

References:

1. J. A. Barrie and D. Machin, "The Sorption and Diffusion of Water in Silicone Rubbers" J. Macromoleculer Sci.-Phys. B3(4), 645 (1969).

2. J. A. Barrie and B. Platt, "The Diffusion and Clustering of Water Vapour in Polymers", Polymer, 4 , 303 (1963).

Copy to:

J.G. Curro (1813)
D.W. Schaefer (1810)
G.D. Grimm (2544)
D.B. Adolf (1813)
P.F. Green (1813)
R.J. Eagan (1800)

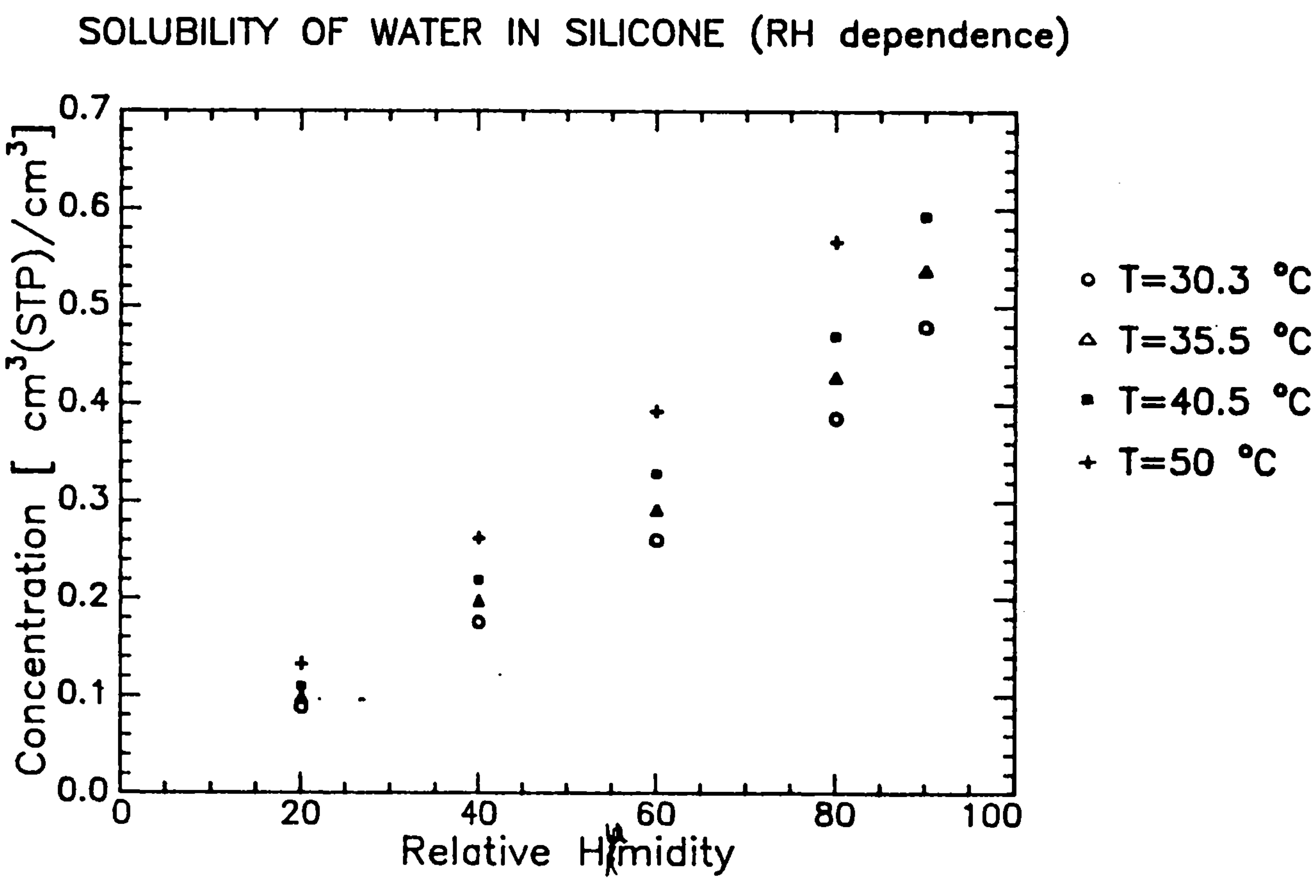

SOLUBILITY OF WATER IN SILICONE (RH dependence)
Concentration [cm3(STP)/cm3]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
20
40
60
80
100
Relative Humidity
T=30.3 °C
T=35.5 °C
T=40.5 °C
T=50 °C

FIG. 1

SOLUBILITY OF WATER IN SILICONE (temp. dependence)

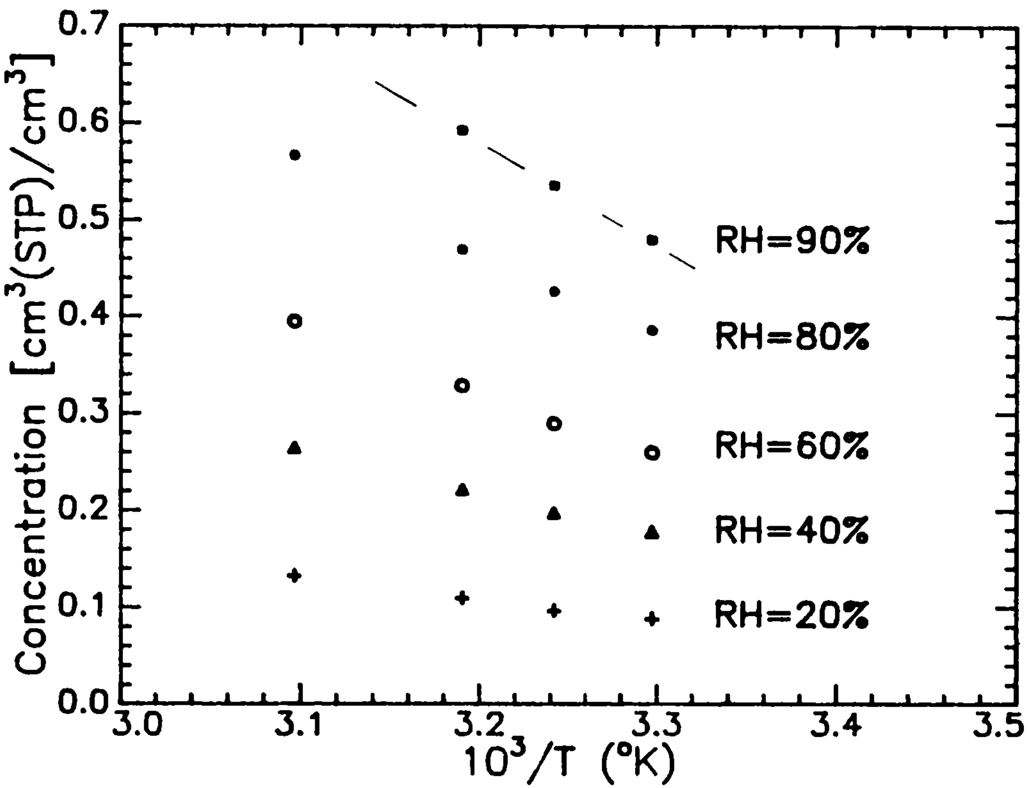


FIG. 2

Allied-Signal Aerospace Company
Kansas City Division
P O Box 419159
Kansas City, MO 64141-6159

Allied Signal

March 21, 1991

Gordon L. Grimm, Org. 2544
Sandia National Laboratories
P.O. Box 5800
Albuquerque, N. M. 87185

Dear Gordon:

Attached is the report of the work on the HVLI Silicone Screening Study you've been requesting. Hopefully, it will be self-explanatory. If not, please feel free to call me with any questions you may have.

Sincerely yours,

M. H. Wilson

M. H. Wilson
Staff Materials Engineer
D/837-2C43

MHW/mhw

Attachment

cc: D. A. Beach, D/824, w/ attachment
D. R. Evans, D/824, w/ attachment
H. C. May, D/837, w/ attachment
H. M. McIlroy, D/837, w/ attachment
H. M. Smith, D/837, w/ attachment
J. A. Stuckey, D/834, w/ attachment

D. E. Carnicom, SNLA 2551, w/ attachment
E. T. Cull, SNLA 8154, w/ attachment
R. L. Meyers, SNLA 7472, w/ attachment
K. T. Gillen, SNLA 1812, w/ attachment
R. D. Sauls, SNLA 8155, w/ attachment

SILICONE ELASTOMER SCREENING STUDY FOR THE HVLI

M. H. Wilson
Department 837

Final Report on 04535800
M. H. Wilson, Project Leader

Project Team: **H. C. May**
M. H. Wilson

SUMMARY

Nine silicone elastomers underwent a screening study to choose the best candidate sealing material for the HVLI (High Voltage Low Inductance) seal on the W89. The nine candidates were tested for stress relaxation and compression set after 24 hours at 177°C. Dow Corning's 747U was chosen as the best candidate material and underwent more extensive stress relaxation testing to help predict long term reliability. Stress relaxation and compression set were measured on post cured and unpost cured samples that were aged for 150 days minimum at 23, 80, 95, and 110°C. These times and temperatures were chosen to detect any chemical activation energy that was as low as 15 Kcal/mol. No evidence of chemical relaxation effects was discovered. Therefore, 747U will have good long term reliability and is recommended for use for the HVLI seal.

DISCUSSION

SCOPE AND PURPOSE

The HVLI (High Voltage Low Inductance) connector requires an elastomeric seal for use as both an environmental and dielectric seal on the W89 program. Silicone elastomers represented the best combination of desired properties for use as the sealing material. Nine candidate silicone elastomers were chosen for a screening study evaluation to determine the best candidates for final qualification testing. Stress relaxation testing was performed to insure that the chosen material would retain adequate sealing force throughout stockpile lifetime.

ACTIVITY

Screening Study

The attributes felt necessary for proper sealing of the HVLI were good dielectric properties, low temperature flexibility, long service life, adequate sealing force, low compression set, and good stress relaxation behavior. Silicone elastomers have all these qualities and were the material of choice for this application. Table 1 contains nine silicone elastomers that were chosen by Gordon Grimm, SNLA 2544, and I for a KCD screening study evaluation. The screening study would determine the best candidate for a more complete stress relaxation qualification testing.

The stress relaxation testing was performed under compression and was used to compare the relative aging behavior between the silicone materials. The stress relaxation test procedure consists of stacking three disks (approximately 1.6 mm thick by 12.7 mm diameter) within each of three stress relaxation fixtures. The stacked samples are then compressed by approximately 25%. One to two minutes after compressing the samples, the initial resultant compressive force is measured. The fixtures are then placed in an oven at the desired aging temperature. The fixtures are removed from the oven, allowed to cool to room temperature for approximately 2 hours, and the resultant compressive force is again measured. The amount of decay in force is the stress relaxation and any permanent decrease from original sample height is the compression set. At the completion of the test, the compression set is measured for the 3 samples 30 minutes after the material is removed from the fixtures. For this screening study, the candidate's stress relaxation behavior was determined after aging at 177°C for 24 hours.

Table 1. Candidate Silicone Elastomers.

Manufacturer	Product	Nominal Hardness, Shore A
Dow Corning	745U	40
Dow Corning	LCS740	40
General Electric	SE6140	40
Dow Corning	55U	50
General Electric	SE4404	50
General Electric	SE6660	60
Dow Corning	747U	70
General Electric	SE3723	70
General Electric	SE6180	80

Figure 1 shows the average initial and final compressive force of the candidates. Figure 2 shows the stress relaxation results as a percent of the original stress. Table 2 contains the compression set $\pm \sigma$ results obtained after the stress relaxation testing. From these data, Dow Corning 747U was felt to be the best candidate for final qualification testing. 747U was chosen for the following reasons:

1. There is extensive production and stockpile history with 747U because it has been used for ribbed pressure pads on the B61 and W83 programs. These applications also require good compression set and stress relaxation properties.

2. 747U is formulated to have fewer manufacturing steps because it does not require a post cure step. Nevertheless, it is still designed to have good compression set resistance without post cure as indicated in Table 2.

3. The final compressive force after the screening study testing was the highest of all the candidates after the same aging exposure.

Table 2. Average Compression Set After 24 hrs @ 177°C.

Material	Compression Set ± σ, %
745U	13.3 ± 1.1
LCS740	10.9 ± 0.8
SE6140	27.6 ± 0.1
55U	30.0 ± 0.2
SE4404	13.1 ± 0.9
SE6660	*
747U	15.9 ± 0.1
SE3723	16.9 ± 0.8
SE6180	20.0 ± 1.8

*Unable to measure because sample stuck to fixture.

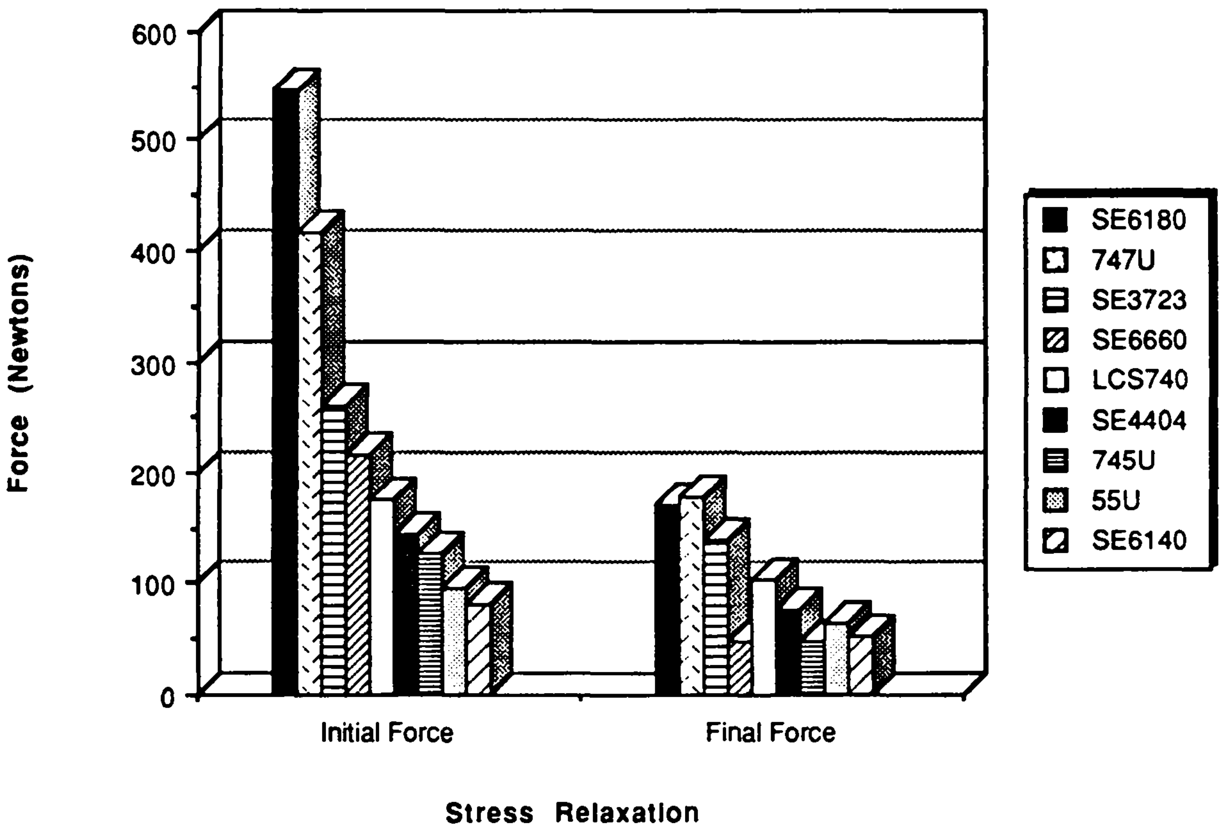


Figure 1. Average Compressive Force Before And After Aging At @ 177°C For 24 Hours.

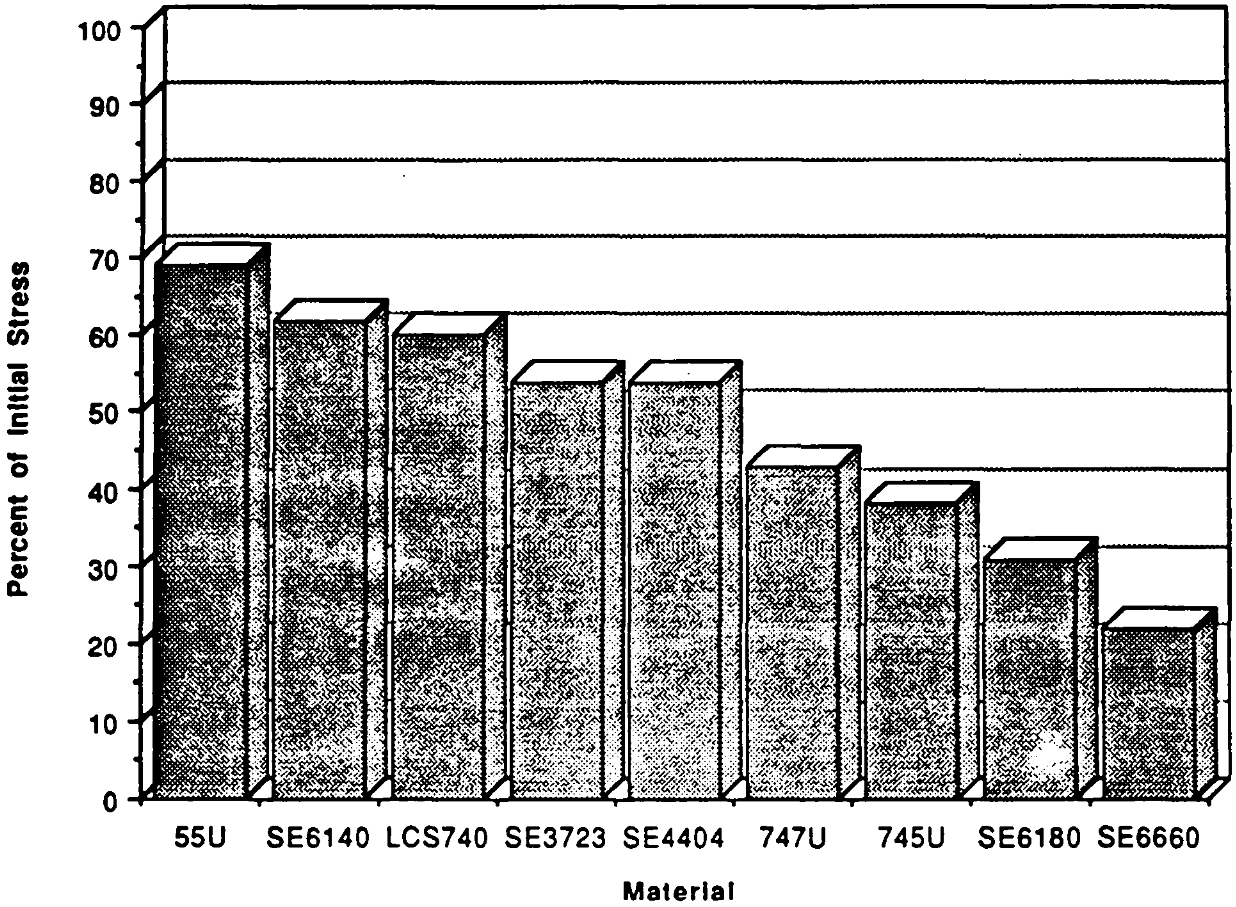


Figure 2. Average Stress Relaxation After 24 Hours @ 177°C.

<u>Stress Relaxation Study Of 747U</u>

After the screening study established 747U as the prime candidate, it was necessary to verify the material would have good stress relaxation behavior throughout stockpile lifetime. Good stress relaxation behavior insures that an adequate sealing force is maintained thus preventing premature failure. Therefore, an accelerated aging experiment was performed that would detect the presence of any detrimental long term stress relaxation within a relatively short testing time.

The stress relaxation process comprises both chemical and physical relaxation effects. Chemical relaxation effects involve the breaking and/or rearrangement of covalent bonds, whereas physical relaxation effects involve physical processes such as diffusion of polymer chain units or the rearrangement of entanglements. Remove the applied stress and the effects of physical relaxation will reverse over time to near the original condition. Chemical relaxation effects are irreversible and the physical dimensions of the rubber are permanently changed (compression set). For short times, the physical relaxation mechanism dominates the stress decay in an elastomer. For long times, such as stockpile lifetime, the chemical decay mechanism dominates the stress relaxation and is therefore the more important reaction for long-term service life predictions.

To determine the detailed chemical mechanism of the stress relaxation would have been beyond the scope of this project. However, a detailed knowledge of the chemical mechanism is not necessarily required to predict future stress relaxation behavior. Instead, accelerated aging was used to detect any chemical relaxation effects by assuming the reaction follows classical Arrhenius-like behavior.

Arrhenius-like behavior also permits a time-temperature superposition to determine the equivalent age of samples undergoing aging at the highest aging temperature. In other words, one can calculate the time required to achieve the same degree of aging at a lower temperature that was actually obtained at the higher aging temperatures. This method assumes that a function describing the stress relaxation can be expressed as some linear function of time.

If the degree of aging of two samples maintained at different temperatures for different lengths of time is equivalent, then the stress relaxation resulting from chemical reactions within the two must also be equivalent. Table 3 shows the equivalent age in years at 40°C which would result from 150 days accelerated aging at several higher temperatures for aging processes with Arrhenius activation energies of 10, 15, 20, and 25 Kcal/mol.

Table 3. Equivalent Age In Years At 40°C After 150 Days Accelerated Aging At T_X.

	E_a, Kcal/mol			
T_X, °C	10	15	20	25
80	2.5	6	16	39
95	4.5	15	50	165
110	7.7	33	145	629

The aging times and temperatures in Table 3 were used for the accelerated aging of 747U. These conditions were chosen to represent the most conservative, worst case scenario for the activation energy leading to possible chemical relaxation within 747U. Therefore, approximately 150 days aging at 80°, 95°, and 110°C were chosen to detect evidence of any chemical relaxation effects arising from a very low activation energy of 15 Kcal/mol. Most thermoxidation reactions causing chemical stress relaxation in rubbers are generally 20 to 30 Kcal/mol. In addition, stress relaxation was also measured at room temperature, 23°C, for 216 days. Multiple temperature testing would allow the actual activation energy to be calculated by superposition techniques if there was any evidence of chemical decay.

Even though 747U is specifically formulated to have low compression set without a post cure, for some materials, post curing may still provide improved compression set performance. Therefore, stress relaxation was run on 747U samples that were either unpost cured or post cured for 4 hours at 205°C. Only the unpost cured 747U was run at 23°C. Figure 3 and Figure 4 shows the stress relaxation results for unpost cured and post cured 747U respectively. The stress relaxation for the post cured 747U is slightly greater than with the unpost cured 747U samples but otherwise the overall trend in the data is the same for both kinds of samples.

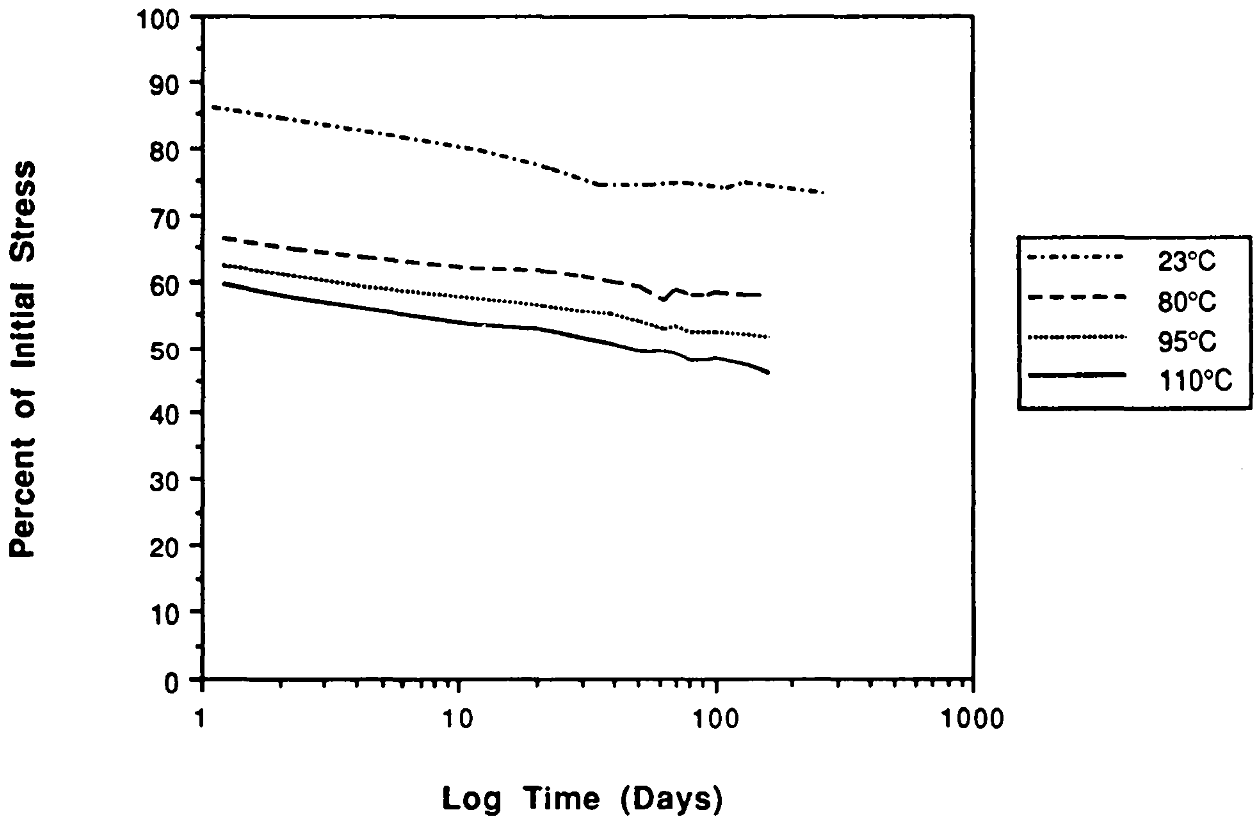


Figure 3. Average Stress Relaxation For Unpost Cured 747U.

When stress relaxation data is plotted versus the logarithm of time, the physical relaxation processes are generally linear and the chemical relaxation is represented by a downward curving trend. Figures 3 and 4 show the data to be linear, not curved. Therefore, the accelerated aging of 747U is dominated by physical relaxation effects and no chemical relaxation is apparent at these aging temperatures. Consequently, 747U is recommended for use as the HVLI sealing material.

Table 4 contains the average compression set values for the samples after stress relaxation testing. The scatter for the unpost cured 747U samples was large for the 110°C aged samples; nevertheless, the overall compression set values are very low after aging for 162 days at the elevated temperature. It also appears that the post cure step may be somewhat detrimental since it produces greater compression set and slightly greater stress relaxation. Therefore, a post cure step is not recommended. Along with the good historical performance of the ribbed pads in the other weapon

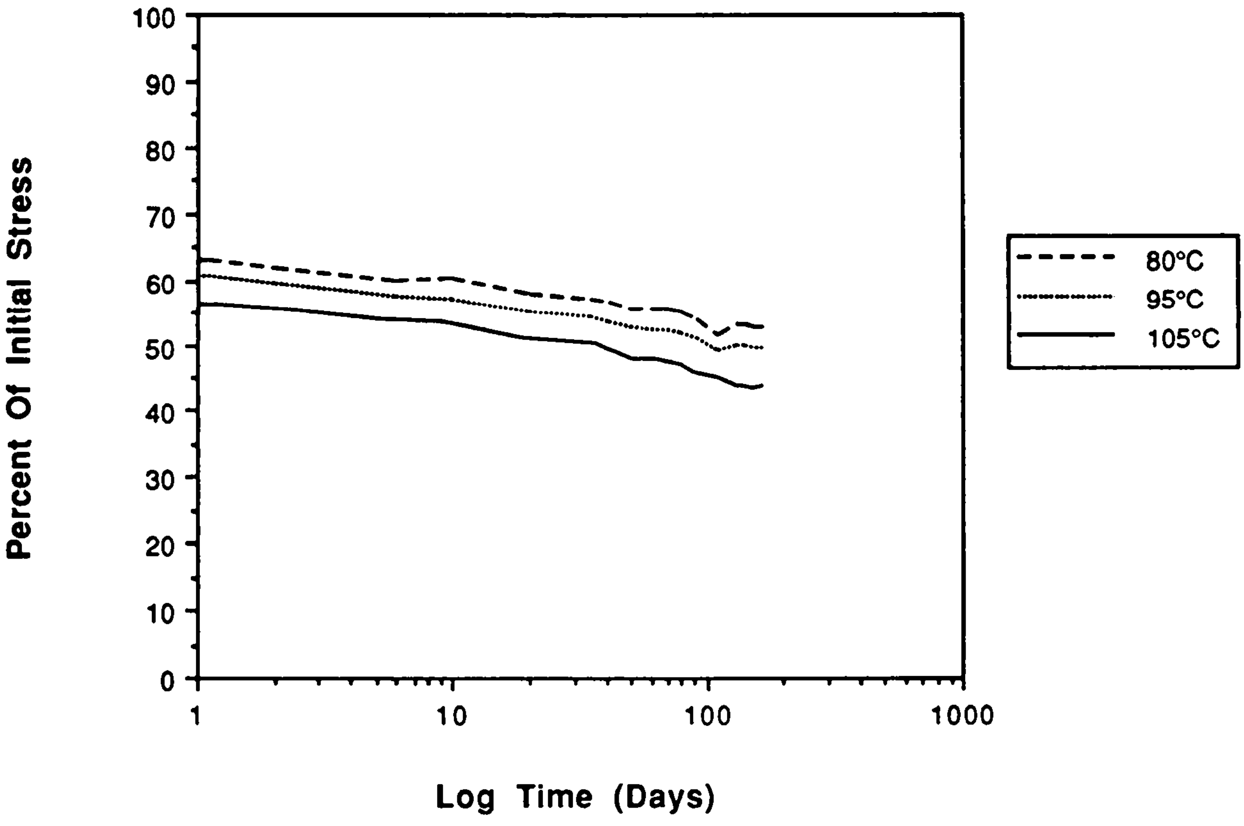


Figure 4. Average Stress Relaxation For Post Cured 747U.

Table 4. Average Compression Set ± σ Of 747U After Aging 162 Days.

	Average Compression Set ± σ, %	
Temperature, °C	Unpost Cured	Post Cured
80	3.8 ± 1.3	10.6 ± 1.1
95	7.4 ± 2.0	10.7 ± 0.6
110	9.1 ± 5.3	15.9 ± 2.0

systems, the stress relaxation and compression set data again demonstrates the superior aging resistance of 747U.

FUTURE WORK

If 747U should become unavailable, SE3723 is felt to be the best material as an alternate. Stress relaxation testing is also planned for SE3723 as a final qualification test.

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: 4/25/89

to: G. Grimm, 2551

Douglas Adolf C. Childress

from: D. Adolf and C. Childress, 1813

subject: Thermophysical Properties of Silicone Elastomers

Your present design for the high voltage low inductance (HVLI) connector in the W89 firing set (MC 4069) incoporates a silicone gasket. You provided us with a list of candidate gasket materials and asked us to characterize their thermophysical properties. The materials are as follows: SE4404U, SE6140, SE6660, DC55U, DC745, and LCS740. We have measured the shear modulus and coefficient of thermal expansion (CTE) as functions of temperature for these materials. The shear moduli from -80 to 90^{0}C are shown in the attached Figures 1 - 6, and the room temperature, rubbery shear moduli are listed in Figure 1. The CTE's over the range from -40 to 100^{0}C were temperature insensitive, and their values are also listed in Table 1 with the glass transition temperatures for these materials. You indicated that SE4404U and 6140 were currently your top choices based on literature compression set values. We attempted to determine the bulk modulus for these by measuring the tensile and shear moduli and calculating the bulk modulus from these. This procedure is extremely sensitive to errors, and we found the calculated bulk moduli to be unsatisfactory. We feel that the a better way to determine the bulk modulus when we cannot *directly* measure it is as follows: (1) measure the glassy shear modulus, (2) assume a Poisson's ratio of ~ .37, (3) calculate the glassy bulk modulus, and (4) assume that the rubbery bulk modulus is a factor of 2 smaller. Although it sounds suspicious, there are reasons for doing this. First, we can measure the shear modulus accurately. Second, we do not want to guess a value for Poisson's ratio in the rubbery state since the rubbery bulk modulus is extremely sensitive to this guess. The glassy bulk modulus is much less sensitive to the estimated glassy Poisson's ratio, and from experience, a choice of .37 is reasonable. Finally, the glassy bulk modulus is almost always twice as large as the rubbery modulus (filled or unfilled systems). This procedure should give estimates of the rubbery bulk modulus that are accurate to within ~30%. We should note that in either the glassy or rubbery regimes the bulk modulus is temperature insensitive. In Table 2, we list the calculated bulk moduli for these silicone materials. We did not list the bulk modulus for SE6660 since its apparent glass transition temperature is much lower than the other silicones, and we cannot measure its glassy shear modulus. The thermophysical properties we have measured are important for determining stresses due to thermal cycling. The stresses are determined by the product of the modulus for a given deformation mode (shear, tensile, or bulk), the CTE, and the temperature difference from the stress free state. In Table 3, we list these measures of thermally generated stresses for each of the silicones. Solely on this basis, we find that SE4404U and LCS740 generate the lowest stress levels with SE6140 and DC55U not that much worse. Of course, the compression set data will be extremely important. We'll keep in touch.

copy to:

1800 R. Eagan
1810 D. Schaefer
1813 J. Curro
1813 D. Adolf
1813 C. Childress
1813 P. Rand
1521 M. Neilsen
1521 S. Burchett
2551 D. Carnicom
7472 J. Sayre
7472 R. Martinez

Table 1: Coefficients of Thermal Expansion, Room Temperature Shear Moduli, and Glass Transition Temperatures of Gasket Materials

material	shear modulus (dynes/cm^2)	CTE ($^0C^{-1}$)	Tg (^{0}C)	
SE4404U	1.3 x 107	271 x 10^{-6}	-50	$-58\,F^{o}$
SE6140	1.7 x 107	222 x 10^{-6}	-50	
SE6660	4.7 x 107	216 x 10^{-6}	-100(?)	
DC55U	1.1 x 107	294 x 10^{-6}	-50	
DC745	2.8 x 107	242 x 10^{-6}	-50	
LCS740	1.2 x 107	268 x 10^{-6}	-50	

$10^{-5}\,N/cm^2$

Table 2: Bulk Moduli for Gasket Materials (dynes/cm^2)

material	glassy shear modulus	glassy bulk modulus	rubbery bulk modulus
SE4404U	3.0 x 10^9	1.1 x 10^{10}	5.2 x 10^9
SE6140	5.0 x 10^9	1.8 x 10^{10}	8.8 x 10^9
SE6660	------	-------	------
DC55U	4.5 x 10^9	1.6 x 10^{10}	7.9 x 10^9
DC745	5.8 x 10^9	2.0 x 10^{10}	1.0 x 10^{10}
LCS740	4.0 x 10^9	1.4 x 10^{10}	7.0 x 10^9

Table 3: Measures of Thermally Generated Stresses

material	shear modulus x CTE	buk modulus x CTE
SE4404U	3.5 x 10^3	1.4 x 10^6
SE6140	3.8 x 10^3	2.0 x 10^6
SE6660	10.2 x 10^3	------
DC55U	3.2 x 10^3	2.3 x 10^6
DC745	6.8 x 10^3	2.4 x 10^6
LCS740	3.2 x 10^3	1.9 x 10^6

Figure 1 SE4404U TEMP:1

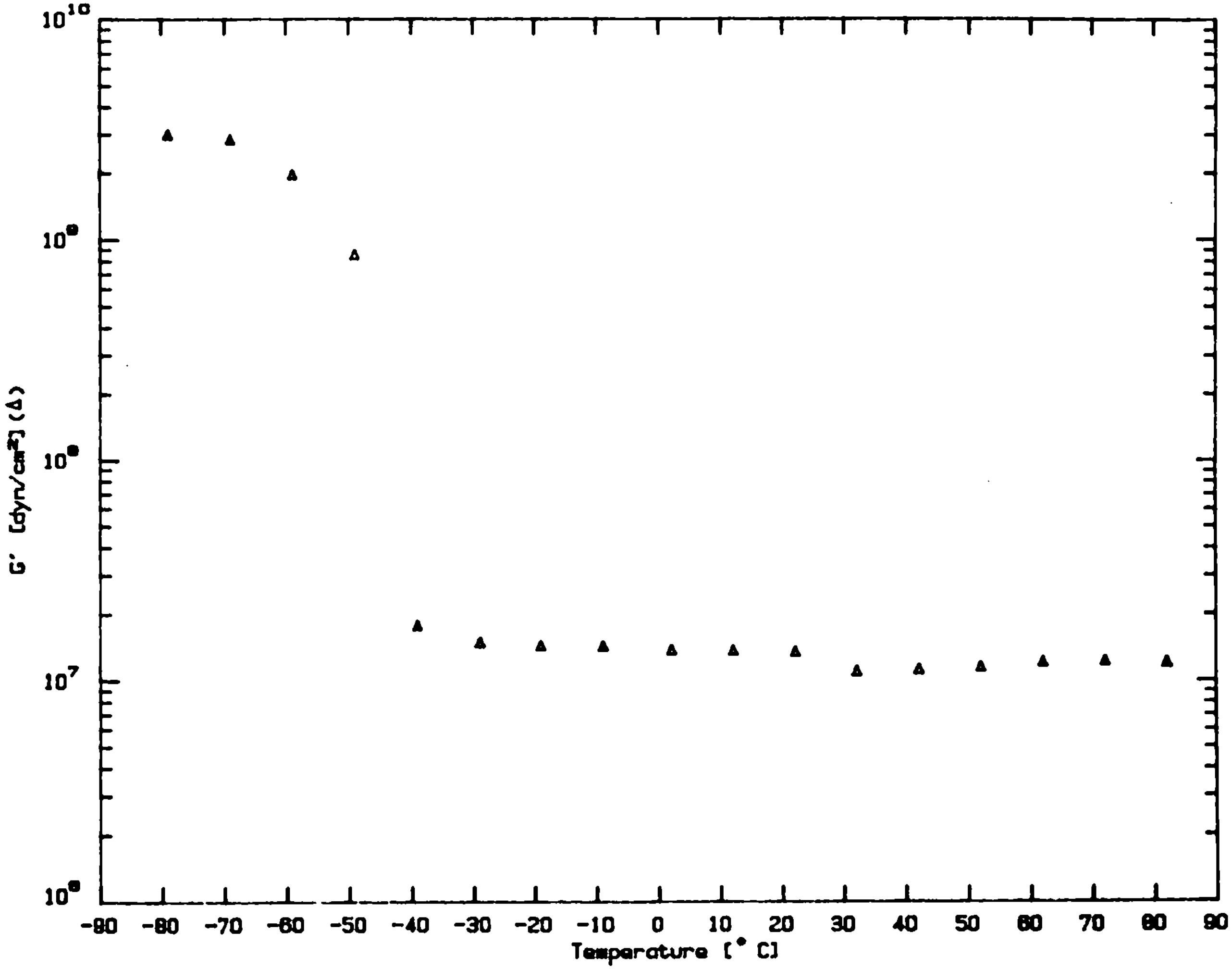


Figure 2 SE6140 TEMP: 1

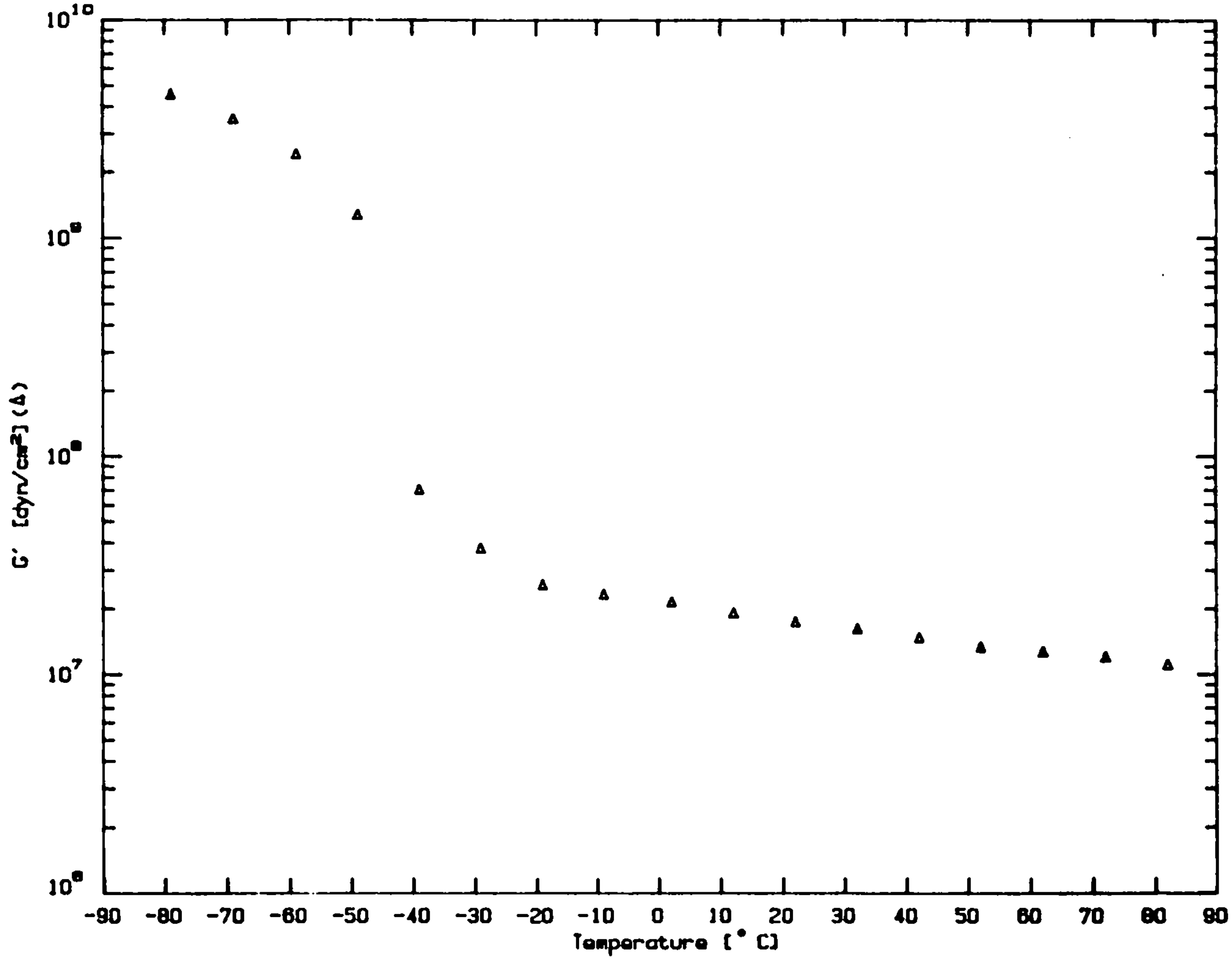


Figure 3 SE6660 TEMP: 2

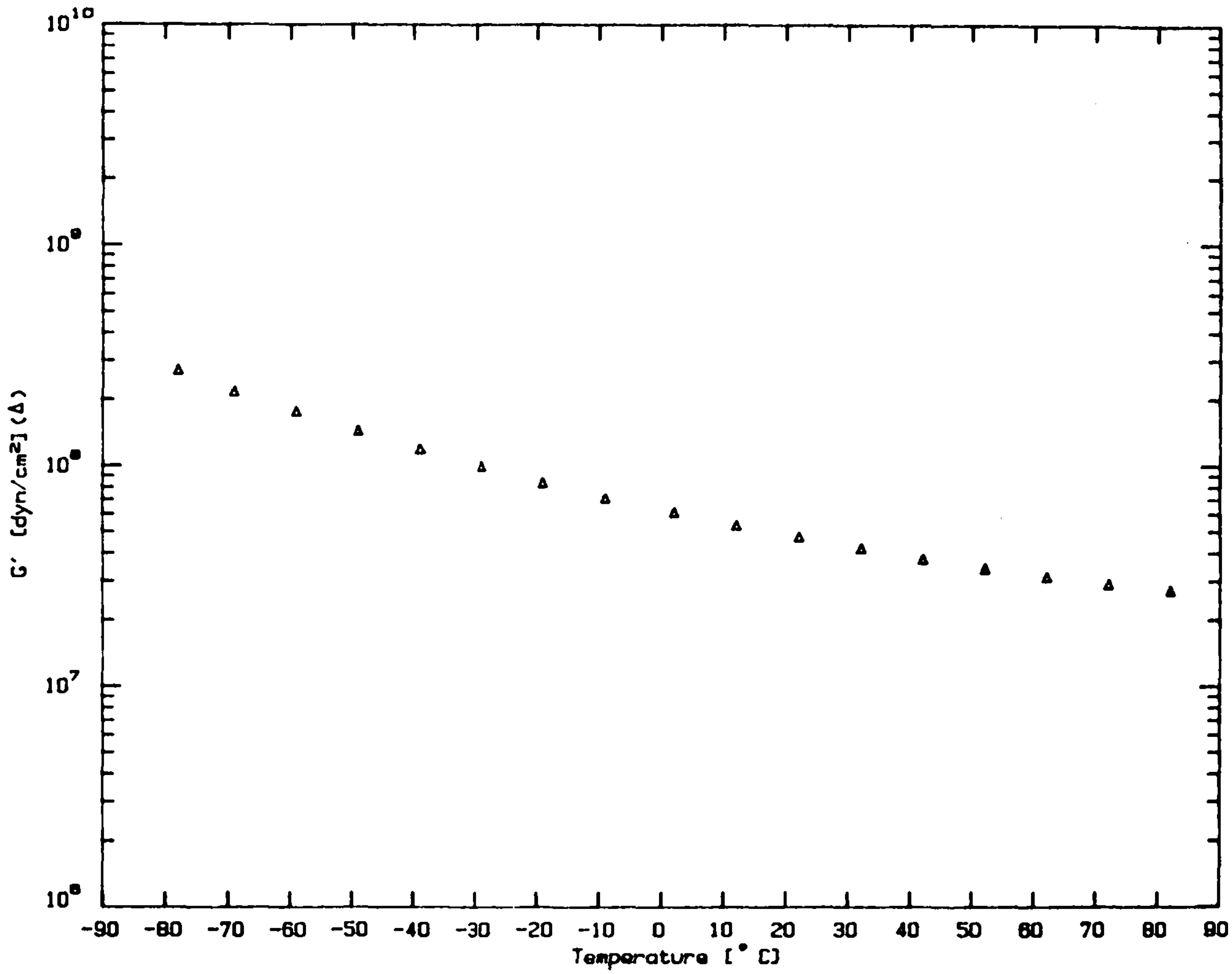


Figure 4

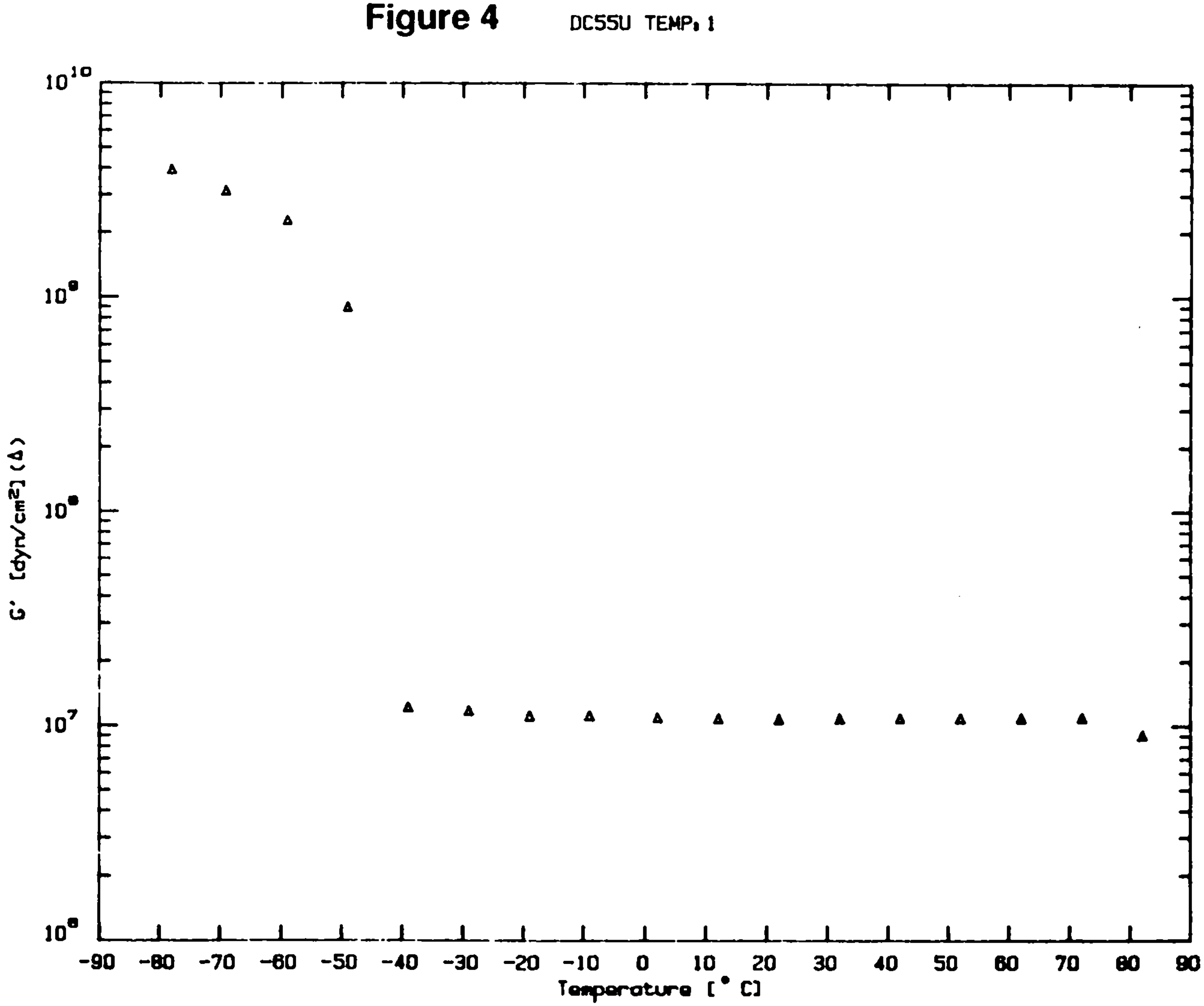


Figure 5

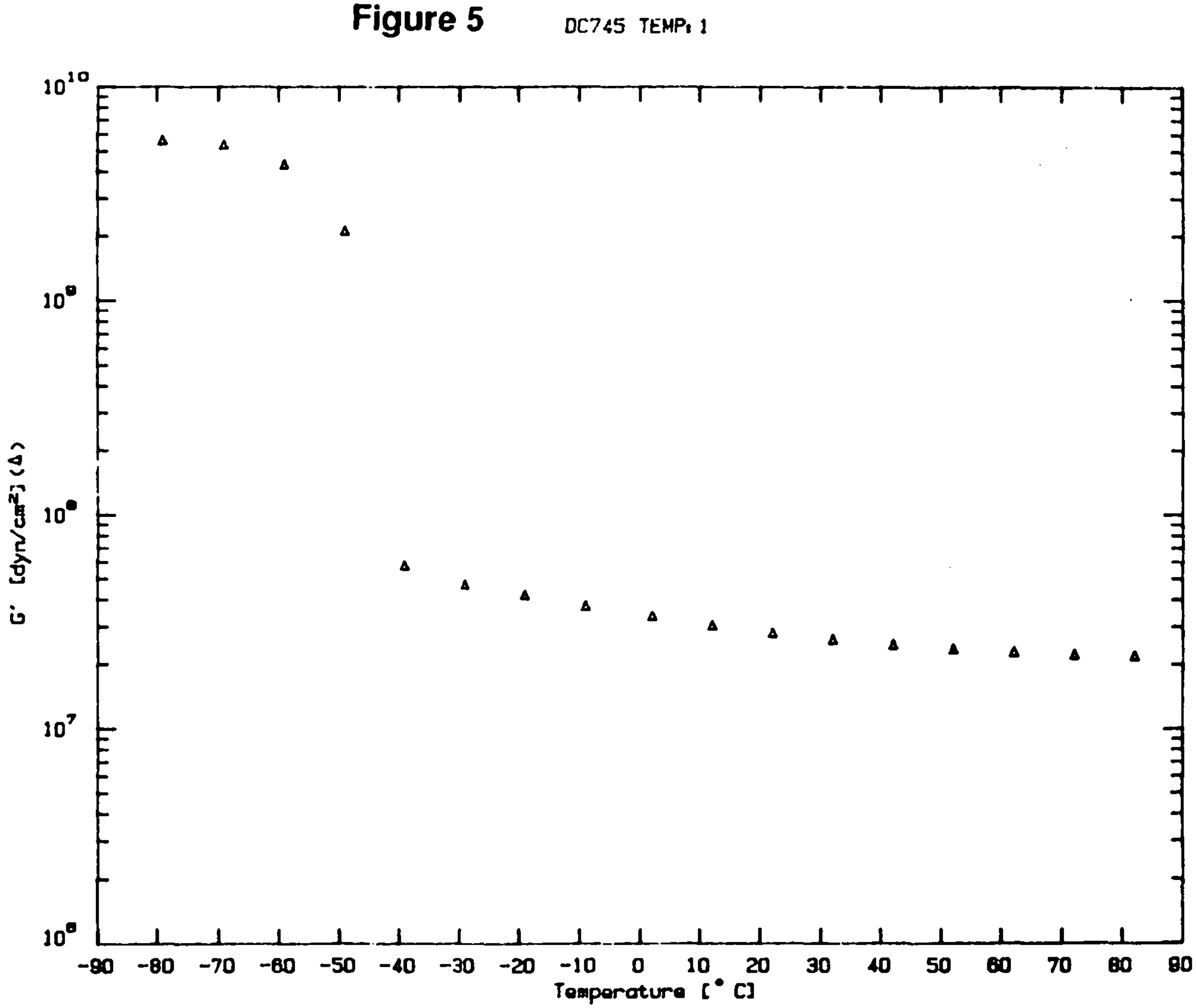
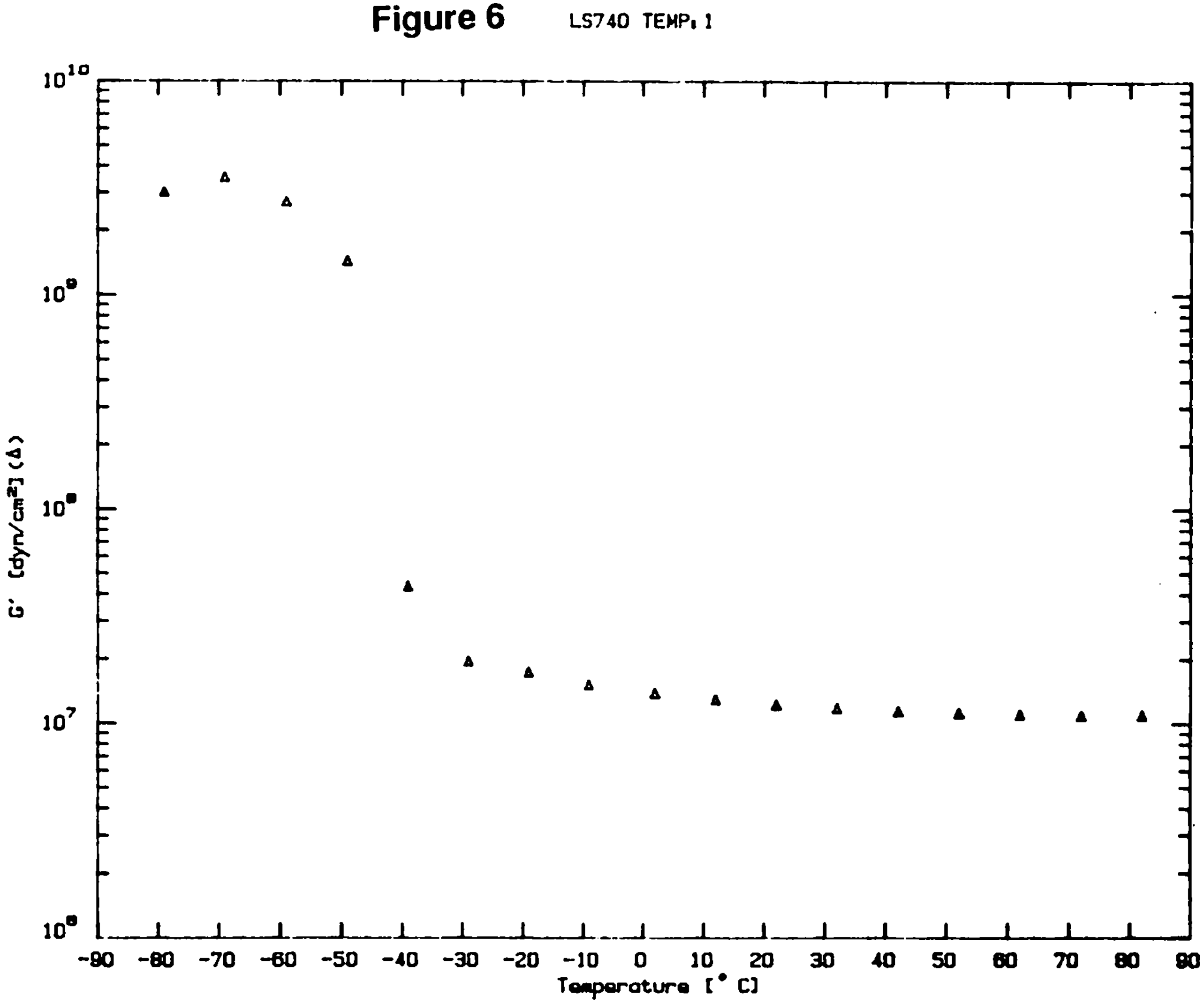

DC745 TEMP: 1
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
G' [dyn/cm²] (Δ)
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
Temperature [° C]

Figure 6



LS740 TEMP. 1
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
G' [dyn/cm²] (Δ)
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
Temperature [° C]

48

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: 8/2/89

to: Mike Nielsen, 1521

Doug Adolf Pete Rand

from: Doug Adolf and Pete Rand, 1813

subject: Viscoelastic Properties for Silicones

At the last meeting for the W89 HLVI connector, we discussed the need for viscoelastic properties for the SE4404 silicone gasket and the Y3223 cellular silicone compression pad. We previously measured the equilibrium moduli for SE4404 and obtained G_∞=190psi, E_∞=570psi, and K_∞=75,000psi (shear, Young's, and bulk equilibrium moduli respectively) which give a Poisson's ratio of 0.5 (incompressible). We also measured the glassy moduli for this material and found G_0=44,000psi, E_0=120,000psi, and K_0=160,000psi. Now, here are the equilibrium moduli for Y3223 cellular silicone: G_∞=55psi, E_∞=140psi, and K_∞=100psi with Poisson's ratio equal to 0.27. Although not directly measured, reasonable estimates of the glassy moduli are G_0=5500psi, E_0=14,000psi, and K_0=12,000psi. The temperature dependences for all moduli over the range of interest is negligible. The viscoelastic response for both materials can be estimated as follows:

$$\frac{M(t)}{M_\infty} = 1 + \frac{M_0}{M_\infty N}\sum_{p=1}^{N} e^{-t/\tau_p}$$

with

$$\tau_p = \tau_L / p^2 \quad \text{and} \quad \log \tau_L = \frac{-3(T-223)}{T-81}$$

where M is the modulus of interest, t is in seconds, T is in Kelvin, and N should be at least 3. Here, the temperature dependence of the relaxation time τ_L is dramatic and given by the second equation above. With this information, you should be able to predict the viscoelastic response as a function of time at any temperature. As an additional bonus (!), we included historical information concerning the aging of a cousin of Y3223 cellular silicone at room temperature. The attached plot shows the percent of original load as a funtion of aging time.

copy to:
1810 Dale Schaefer
1813 John Curro
2551 Gordon Grimm

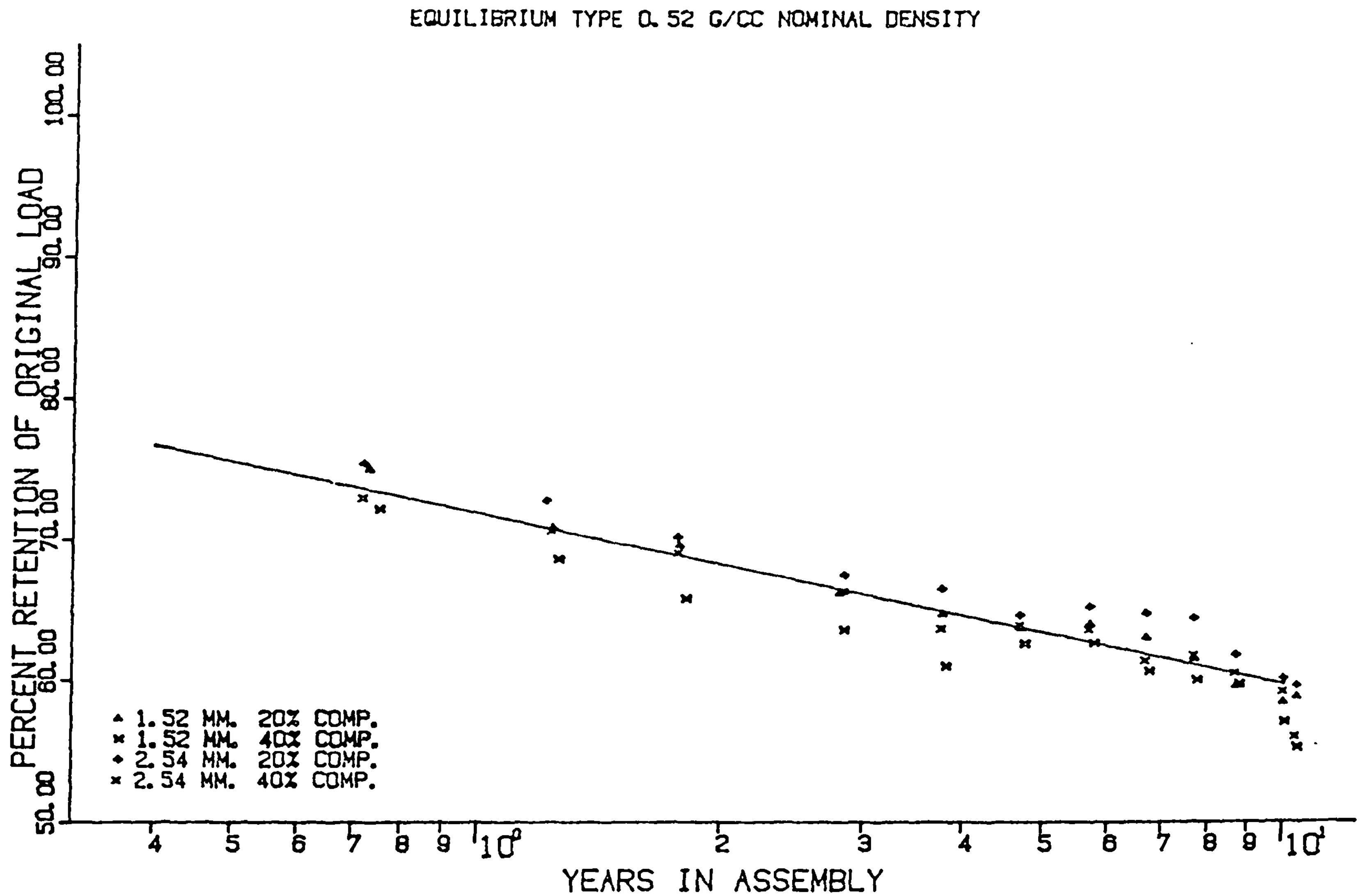


Figure 6. Percent Retention Versus Natural Log Time for Equilibrium-Type Material, 0.52 g/cm^3 Nominal Density

APPENDIX D

Development Testing

PO 63-5160 Amendment 7
STATEMENT OF WORK

1.0 Environmental Testing:
A series of environmental tests will be performed to evaluate the Contact and Seal Assembly (CSA) design.

1.1 Phase V:

1.1.1 Description:
A total of 12 Main CDU CSA will be selected and subjected to the following tests:

QTY	TEST	PARA
3	Temp Cycle	2.1
3	Shock	2.2
3	Vibration	2.3
3	Temp,Shock,Vibration	2.1,2.2,2.3

Insulation Resistance per paragraph 2.5 and Contact Resistance per paragraph 2.4 will be done on each test unit before and after each series of tests.

1.1.2 Hardware:
Test units will be supplied by SNL from parts purchased on PO 69-0294 from Stillman Seal.

The following test fixtures and cables will be supplied by Allied/Signal KCD.

NAME	DEFINITION
Main Mounting Block	SS388316-D
Main Compression Lid	SS388316-D
Main CDU cable	SS388316-D
Main Det Cable	SS388316-D

1.2 Phase VI:

1.2.1 Description:
A total 20 Main CDU CSA, 20 NG CDU CSA and 20 Series CSA will be selected and tested as follows:

QTY	TEST	PARA
5	Temp Cycle	2.1
5	Shock	2.2
5	Vibration	2.3
5	Temp,Shock,Vibration	2.1,2.2,2.3

Insulation Resistance per paragraph 2.5 and Contact Resistance per paragraph 2.4 will be done on each test unit before and after each series of tests.

1.2.2 Hardware:
Test units will be supplied from ICO 69-0289 with Allied/Signal KCD.

NAME	DEFINITION
Main CSA	392920-00
NG CSA	392921-00
Series CSA	392922-00

The following fixtures and test hardware will be supplied by Allied/Signal KCD:

NAME	DEFINITION
Main Mounting Block	SS388316-D
Main Compression Lid	SS388316-D
Main CDU cable	SS388316-D
Main Det Cable	SS388316-D
NG Pocket	SS388317-D
NG Compression lid	SS388317-D
NG CDU cable	SS388317-D
NG Det cable	SS388317-D
Series Pocket	SS319420-B
Series Compression Lid	SS319420-B

Test cables for the Series interface will be supplied by SNL and modified by Allied/Signal KCD for this test.

1.3 Low Temperature:

1.3.1 Description:

A total of 3 Main CSA will be subjected to Temperature Cycling described in paragraph 2.1. An Insulation Resistance test per paragraph 2.5 will be done at room temperature prior to the Temperature Cycling. Following the Temperature Cycling the units under test will be subjected to an Insulation Resistance test, per paragraph 2.5, while maintaining a maximum temperature of -55 degrees F.

1.3.2 Hardware:

Test units will be supplied by SNL from parts purchased on PO 69-0294 from Stillman Seal. The following fixtures and test hardware will be supplied by Allied/Signal KCD:

NAME	DEFINITION
Main Mounting Block	SS388316-D
Main Compression Lid	SS388316-D
Main CDU cable	SS388316-D
Main Det Cable	SS388316-D

1.4 Solvent Exposure:

1.4.1 Description:

A total of 4 Main CSA will be subjected to thermal cycled per paragraph 2.6.1. A control unit will be exposed to the same cycle but will not have D-limonene present in the container. Insulation Resistance per paragraph 2.5 will be performed before and after exposure and the maximum current leakage will be recorded.

A total of 4 Main CSA will be aged per paragraph 2.6.2. A control unit will be exposed to the same aging but will not have D-limonene present in the container. Insulation Resistance per paragraph 2.5 will be performed before and after exposure and the maximum current leakage will be recorded.

1.4.2 Hardware:

Test units will be supplied by ICO 69-0289 with Allied/Signal KCD. The following fixtures and test hardware will be supplied by Allied/Signal KCD:

NAME	DEFINITION
Main CSA	
Main Mounting Block	SS388316-D
Main Compression Lid	SS388316-D
Main CDU cable	SS388316-D
Main Det Cable	SS388316-D

2.0 Test Description:

2.1 Temperature Cycle:

Units will be subjected to 100 cycles of -55 F to 160 F starting at room temperature. Transition time between high and low temperatures will be 30 minutes. Dwell time at high and low temperature will be 30 minutes. Test units will be measured every 10 minutes for open circuits greater than 50 ohms. Data will be submitted in the form of a 3.5 inch or 5.0 inch magnetic disk compatible with IBM PC/AT or PS2.

2.2 Shock:

Test units will be subjected to a 2000 G, 2 millisecond mechanical shock in each of the major axes. Test units will be monitored for open circuits greater than 50 ohms resistance and greater than 1.0 microseconds in duration.

2.3 Vibration:

Test units will be subjected to 1.0 G*G/Hz random vibration from 20 to 2000 Hz for 1.5 minutes per axis in each of three major axes. Test units will be monitored to opens greater than 50 ohms and greater than 1.0 microseconds in duration.

2.4 Contact Resistance:

Measure contact resistance at 1.0 amps. Each reading will be recorded and submitted with the test data.

2.5 Insulation Resistance:

Apply a voltage of 10 KV dc to the test unit while at room pressure and temperature. Reduce the pressure in test chamber from room to 0.1 torr and hold for 2.0 minutes minimum. Current leakage will be no greater than 10 microamps.

2.6 Solvent Exposure:

2.6.1 Thermal cycle age 100 cycles in an atmosphere of 0.05% by volume D-Limonene, -65 degrees F to 160 degrees F, 4 hours between temperatures, 4 hours dwell at high and low temperature. Test units will be in a sealed container that has been backfilled with nitrogen.

Perform Insulation Resistance per paragraph 2.5.

Isothermal age at 160 degrees F for 6 months. Perform Insulation Resistance per paragraph 2.5 after 1, 3 and 6 months in an atmosphere of 0.05% by volume D-Limonene.

2.6.2

Isothermal age at 160 degrees F for 6 months in an atmosphere of 0.05% by volume D-Limonene. Perform Insulation Resistance per paragraph 2.5 after 1, 3 and 6 months. Test units will be in a sealed container that has been backfilled with nitrogen.

Perform Insulation Resistance per paragraph 2.5.

Thermal cycle age 100 cycles in an atmosphere of 0.05% by volume D-Limonene, -65 degrees F to 160 degrees F, 4 hours between temperatures, 4 hours dwell at high and low temperature.

Memorandum

Allied-Signal Aerospace Company

Kansas City Division
Kansas City, Missouri

Allied Signal

Date: June 25, 1989

To: Gordon Grimm, SNLA 2551

From: D. A. Beach, KCD 824

Subject: TEST RESULTS OF SERIES HVLI INTERFACE UNITS

Ten units were tested to the requirements of our Engineering Services order 63-5160 and per your instructions.

The test units were constructed as follows:

> The flex cables used were the ones you made at SNLA and sent to me. I attached lead wires (approximately 12 inches in length) to the cables and potted the solder connections.
>
> Mounting blocks and lids used were the ones you had provided.
>
> The KCD made springs (391446) were supplied to Mound for them to solder together using various methods and solder.
>
> The contact and seal assemblies came from Mound and was made of milled DAP material with glued-on RTV o-rings seals. The springs were then glued to the contact and seal assemblies at Mound.

The units were tested using the following sequence:

CONTACT RESISTANCE - The dc resistance was measured and recorded

HI-POT - A 10 kV voltage was applied and the chamber pumped down to a vacuum of ~3 torr. The units were under the 10 kV voltage from start of pump down until the chamber was returned to atmosphere. The chamber was at altitude for 120 seconds.

ACCELERATED LIFE - The testing consisted of 95 cycles, starting from room temperature to -55^{o}F to 160^{o}F. The duration at each temperature was 30 minutes. The transition time between each temperature was the actual time the chamber needed (~60 minutes).

RANDOM VIBRATION - The test consisted of a 1 g^2/Hz, 20 - 2000 hz, 1 1/2 minutes/axis with continuously monitoring for any discontinuity that exceeds 50 ohm for 1 microsecond.

MECHANICAL SHOCK - The units were Mechanical Shock tested at 2000 G's for a duration of 2 MS applied to three planes in both directions. The continuity was continuously monitored for any discontinuity exceeding 50 ohms for 1 microsecond.

CONTACT RESISTANCE - The resistance was measured and recorded using the same conditions as above.

HI-POT - The units were retested using the same conditions as above hi-pot test.

Test results:

ACCELERATED LIFE : All units passed.

MECHANICAL SHOCK : All units passed.

CONTACT RESISTANCE : See Electrical Test Results below.

HI-POT : See Electrical Test Results below.

ACCELERATED LIFE DATA: See attached data sheets.

The design concept of Contact and Seal Assemblies, was verified by this testing. Although some units failed the Hi-Pot testing, the cause of the failures was not because of the HVLI interconnect.

Attached to this memo is the resistance data from the Accelerated Life testing. This information was transcribed from the tester print-out rolls. Data was taken every 10 minutes during the test. I only included data from the first 20 cycles and then for every 5 cycles after that.

ELECTRICAL TEST RESULTS:

UNIT NUMBER	TYPE OF SPRING SOLDER		CONTACT RESISTANCE BEFORE mOHM	CONTACT RESISTANCE AFTER mOHM	HI-POT BEFORE MICRO AMP.	HI-POT AFTER MICRO AMP.
1	EUTECTIC SOLDER	A	49.0	48.1	<1	FAIL
2	RESISTANCE BRAZED	B	50.7	50.8	<1	<1
3	HI-TEMP SOLDER	C	49.4	49.6	<1	<1
4	RESISTANCE BRAZED	D	48.5	48.9	<1	<1
5	HI-TEMP SOLDER	E	49.1	49.0	<1	<1
6	RESISTANCE BRAZED	G	48.2	47.8	<1	RETEST <1
7	EUTECTIC SOLDER	H	49.5	49.0	<1	RETEST <1
8	EUTECTIC SOLDER	I	49.1	49.2	<1	<1
9	RESISTANCE BRAZED	J	48.9	48.8	FAIL	RETEST <1
10	HI-TEMP SOLDER	K	47.5	47.5	FAIL	RETEST <1

PRE ENVIRONMENTAL Hi-Pot failure modes:

Unit number 1 had a hard Hi-Pot failure the first time it was run. The unit was torn down and a carbon path found between the seal gasket and lower (long) cable. The carbon path was actually many paths along one end of the cable and seal. The gasket carrier had an interference fit on the dowel pins and RTV seal may not have seated against the cable with a good seal. The cable was replaced and the seal gasket cleaned and unit reassembled. The unit passed Hi-Pot under vacuum this time.

Unit 9 failed the first Hi-Pot test and it was torn down. No failure mode was discovered and the unit was retested. It failed this second test, but due to limited time before units were needed for Accelerated Life test, the unit was sent along with the other parts.

Unit 10 failed the first Hi-Pot test and was found that the short cable had a torn and delaminate kapton area that exposed the conductor. Due to time restraints the unit was not repaired, but was sent along with the other parts for rest of test.

POST ENVIRONMENTAL Hi-Pot failure modes:

Units 6, 7, and 9 were to torn down and all the long cables were found to be damaged where the cable rubbed against the edge of the mounting block. After talking to you, we decided to replace the bad cables with cables from good units and rerun the Hi-Pot test. All three units passed the test after replacement of long cables.

Unit 10 had the short cable replaced (torn and delaminate kapton area) prior to Hi-Pot test. The unit failed and was later torn down and examined. The second cable had a small void from the conductor to the outside contour. This void caused an electrical path to the mounting block. This cable was replaced and unit passed the Hi-Pot test.

Unit 1 failed the Hi-Pot test and had a leakage path on the seal where all the carbon could not be removed from the Pre Hi-Pot failure. The leakage path became conductive during the accelerated life testing.

DAB:db

Atachment

cc: H. A. Oswald, D/824

Memorandum

Allied-Signal Aerospace Company

Kansas City Division
Kansas City, Missouri

Allied Signal

Date: JANUARY 27, 1992

To: G. D. GRIMM, SNL 2554

From: D. A. BEACH, D/842

Subject: **HVLI ENGINEERING SERVICES ORDER 63-5160 REPORT ON INTERIM AND FIRST KCD CONTACT AND SEAL ASSEMBLY TESTING**

This memorandum will report on Electrical and Environmental testing of six Interim Contact and Seal Assemblies and six first KCD development Contact and Seal Assemblies. Included in this report will be how the test units were constructed, how the units were assembled, and how the units were tested. All twelve units were assembled, and tested the using the same procedures.

The test sequence started with electrical testing (contact resistance and insulation resistance) of all units prior to the first environmental test (mechanical shock) and then between each of the other environmental test (temperature cycle and vibration).

All six units of the **KCD C&S** Assemblies passed all the electrical and environmental testing. See the page titled "TEST RESULTS FOR KCD MAIN C&S ASSEMBLIES" for actual electrical test values.

All six units of the **INTERIM C&S** Assemblies passed all the environmental test and all the electrical test except for two units which failed the final Hi-Pot test. Upon examination of the failed units, it was found that the screws had worked loose during the vibration test. The screws were tightened and the units retested. Both units then passed the Hi-Pot retest. See the page titled "TEST RESULTS FOR INTERIM MAIN C&S ASSEMBLIES" for actual electrical test values. All future test units will use WR type screws and will be torqued to 9.25 +/- 0.25 inch pounds.

Attached to this memo are the data of the Temperature Cycling resistance values as monitored during the test. As this is eighty two pages of information, I will not distribute to all parties. The data shows that all units passed the temperature test and the only resistance variation was due to the temperatures variation. This information is be available if wanted.

TEST RESULTS FOR KCD MAIN C&S ASSEMBLIES

TEST	READING	START 7/91	AFTER SHOCK 8/91	AFTER TEMP.CY 10/91	AFTER VIBRATION 12/91
SN 1					
First Contact	milliohm	50.0	50.5	50.4	50.6
Second Contact	milliohm	49.0	49.5	48.9	49.5
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.3
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 3					
First Contact	milliohm	52.0	52.5	51.6	51.4
Second Contact	milliohm	51.4	52.2	50.1	51.2
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 4					
First Contact	milliohm	52.0	52.5	52.2	52.5
Second Contact	milliohm	51.8	52.3	51.7	51.5
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 9					
First Contact	milliohm	52.7	52.4	51.9	52.6
Second Contact	milliohm	51.3	51.4	51.2	51.1
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 10					
First Contact	milliohm	52.6	52.7	52.4	52.7
Second Contact	milliohm	51.6	51.9	51.4	51.7
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 12					
First Contact	milliohm	51.3	51.5	50.8	51.5
Second Contact	milliohm	51.1	51.1	50.8	51.1
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2

TEST RESULTS FOR INTERIM MAIN C&S ASSEMBLIES

TEST	READING	START 7/91	AFTER SHOCK 8/91	AFTER TEMP.CY 10/91	AFTER VIBRATION 12/91
SN 2					
First Contact	milliohm	50.0	50.5	49.9	50.4
Second Contact	milliohm	48.8	49.6	49.3	49.4
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	OHL (<.2)*
SN 5					
First Contact	milliohm	51.5	51.9	51.7	51.9
Second Contact	milliohm	51.6	51.8	51.3	51.5
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 6					
First Contact	milliohm	52.2	52.7	52.0	53.7
Second Contact	milliohm	51.5	51.5	49.5	49.8
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	OHL (<.2)*
SN 7					
First Contact	milliohm	51.0	51.5	50.9	51.1
Second Contact	milliohm	50.6	51.0	50.4	50.7
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 8					
First Contact	milliohm	49.3	49.9	49.3	49.7
Second Contact	milliohm	49.3	49.5	49.1	49.2
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2
SN 11					
First Contact	milliohm	51.6	51.7	51.4	51.6
Second Contact	milliohm	51.3	51.6	51.1	51.5
Hi-Pot to case	micro amp	<.2	<.2	<.2	<.2
Hi-Pot contacts	micro amp	<.6	<.2	<.2	<.2

* This is the retest measurement after tightening the screws.

After all testing was completed, one KCD test unit was modified by removing the top cable and replacing it with a cable that would connect the conductors in series. This allowed the test unit to be Hi-Pot tested using the W89 Firing Set Labs tester. The unit was placed in a large block of Aluminum to act as a heat sink. This block was then placed in a cooler and soaked to a temperature below -65 degrees F. The unit was quickly placed into the Vacuum Chamber and tested. The unit passed a 6 KV dc Hi-Pot test at a vacuum of approximately 0.5 torr.

An explanation of test hardware construction, assembly of test units and test requirements follow:

TEST HARDWARE CONSTRUCTION

MAIN MOUNTING BLOCK . . . Development unit made in KCD Model shop to specifications of 385512-107.

MAIN COMPRESSION LID . . . Development unit made in KCD Model shop to specification of 385517-104.

MAIN CDU CABLE . . . Development unit made to 386854-104 specification and modified by cutting round end of cable off leaving about 3 3/4 inch length of cable containing the HVLI end. A solder window was lasered into the cut off area and 12 inch long wires were soldered to cable for electrical connection to HVLI conductors. The soldered end was then encapsulated with EN-7 potting (approximate size 1.5 X 2 X .4 inch).

MAIN DET CABLE . . . Development unit made to 391724-101 (Dogbone Test Cable) and modified by attaching two 12 inch long wires to the NG mating end. The soldered end of cable was then encapsulated with EN-7 potting (approximate size 1.5 X 2 X .4 inches).

CONTACT AND SEAL (INTERIM) . . . Unit supplied by Gordon Grimm and was made to Sandia Drawing R24250 (Main Carrier Gasket Subassembly) using milled Peek material per R24247 (Main Carrier) and KCD springs per 391446 issue B laser welded back to back.

CONTACT AND SEAL (OLD DESIGN SPRING) . . . Unit made at KCD per Drawing 392920-101 (Carrier Subassembly, Main) and was made from 392897-101 and the original designed spring contacts 393048-101 and laser welded together per

393049-101. These springs had the wide flange that could provide an electrical path under the silicone rubber o-ring.

ASSEMBLY OF TEST UNITS:

INTERIM CONTACT AND SEAL UNITS

All piece parts except the Contact and Seal units were cleaned by spray cleaning with Alcohol and blown dry with plant nitrogen. The Contact and Seals supplied by Gordon Grimm were not cleaned prior to assembly into test blocks.

Each test unit was assembled in D/63 Positive Pressure Room inside a Clean Bench. All piece parts were blown off with plant nitrogen just prior to assembly. A piece of pressure sensitive transfer adhesive was placed on the bottom side of the Main cable to firmly attach Main cable to Mounting Block. The assembly was held together using regular button head socket screws.

KCD CONTACT AND SEAL UNITS

KCD Contact and Seals had been cleaned and packaged per the drawing requirements and were not cleaned prior to assembly. The test units were assembled using the same procedure as the Interim units.

ELECTRICAL TESTING

CONTACT RESISTANCE . . . Each contact was measured for resistance at 1.0 amps and the resistance readings recorded.

INSULATION RESISTANCE . . . A high altitude Insulation Resistance test (Hi-Pot) was preformed by applying a voltage of 10 KV dc to the test unit. This voltage was held on the unit during the complete cycle of the test chamber. The test chamber pressure was reduced to 2.5 torr and held for 2 minutes before slowly bleeding back to room pressure. (The present Test Chamber's lower limit is approximately 2.5 torr.) Each unit was tested by grounding the mounting block (case) and testing both contacts to case and then retesting by moving one contact to case ground and testing between the contacts.

All units were electrical tested prior to each Environmental Test and after the final Environmental Test.

ENVIRONMENTAL TEST

TEMPERATURE CYCLE . . . Units subjected to 100 cycles of -65 F to 160 F starting at room temperature. Transition time between high and low temperatures was approximately 60 minutes, which was controlled by the oven. Dwell time at high and low temperatures was 30 minutes. Test units were measured every 10 minutes for open circuits greater than 50 ohms and readings for each contact recorded.

MECHANICAL SHOCK . . . Test units were subjected to a 2000 G, 2 millisecond mechanical shock in each of the major axis. Test units were monitored for open circuits greater than 50 ohms resistance and greater than 1.0 microseconds in duration.

VIBRATION . . . Test units were subjected to 1.0 G*G/Hz random vibration from 20 to 2000 Hz for 1.5 minutes per axis in each of three major axes. Test units were monitored for opens greater than 50 ohms and greater than 1.0 microseconds in duration.

D.a. Beach

DAB/db

Attachments

CC: w/o attachments

KCD
John Davis, D/343, MY40
Bob Heinen, D/343, MY40
Richard Hubert, D/431, SA-4
Gary Gentry, D/231, 1D40
Ron Obenchain, D/842, 2A32
Dave Shepherd, D/343, MY40

SNL,A
Norb Siska, 2364

SNL,L
Ron Sauls, 8155

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